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NEW LOOK

#167 APRIL 2019

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Welcome

Everything you need to know about choosing your telescope

Over the first week of February we ran our inaugural Back Garden Astronomy Week – helping newcomers to astronomy discover the night sky with one simple thing to observe each night. I'm pleased to tell you it was a resounding success: over 9,000 people signed up to receive the daily email bulletins.

If you're interested in seeing more of what the cosmos has to offer, the first part of our no-nonsense guide to buying a telescope on page 35 is essential reading. Author Tim Jardine has been around telescopes for many years and has expert advice to finding an instrument that's right for you, whether you're after a system that'll show you distant galaxies at the touch of a button, or want to take in the wonders of the Solar System with your family.

Capturing the Solar System on camera is a delicate matter: we have to contend with the blurring effects of the atmosphere above us. Using the right equipment and techniques, though, it is possible to cut through the murk and take photos that are rich in detail. Will Gater shows you how in his introduction to planetary imaging on page 63.

You might think that the pursuit of astronomy is an exclusively outdoor hobby, but there are many reasons why you might want to do it indoors – weather, health and lack of dark skies to name but a few. The good news is that our feature on page 28 will convince you that there is much astronomy that can be done under cover and, as author Steve Richards explains, that includes using a telescope.

Enjoy the issue,



Chris Bramley, Editor

PS Our next issue goes on sale 18 April.

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Sky at Night – lots of ways to enjoy the night sky...



Television

Find out what *The Sky at Night* team will be exploring in this month's episode on page 17



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The best targets to observe each week, delivered direct to your inbox: **bit.ly/sky-enews**



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The incredible legacy of NASA's planet-hunting scope and how it changed our view of the Universe

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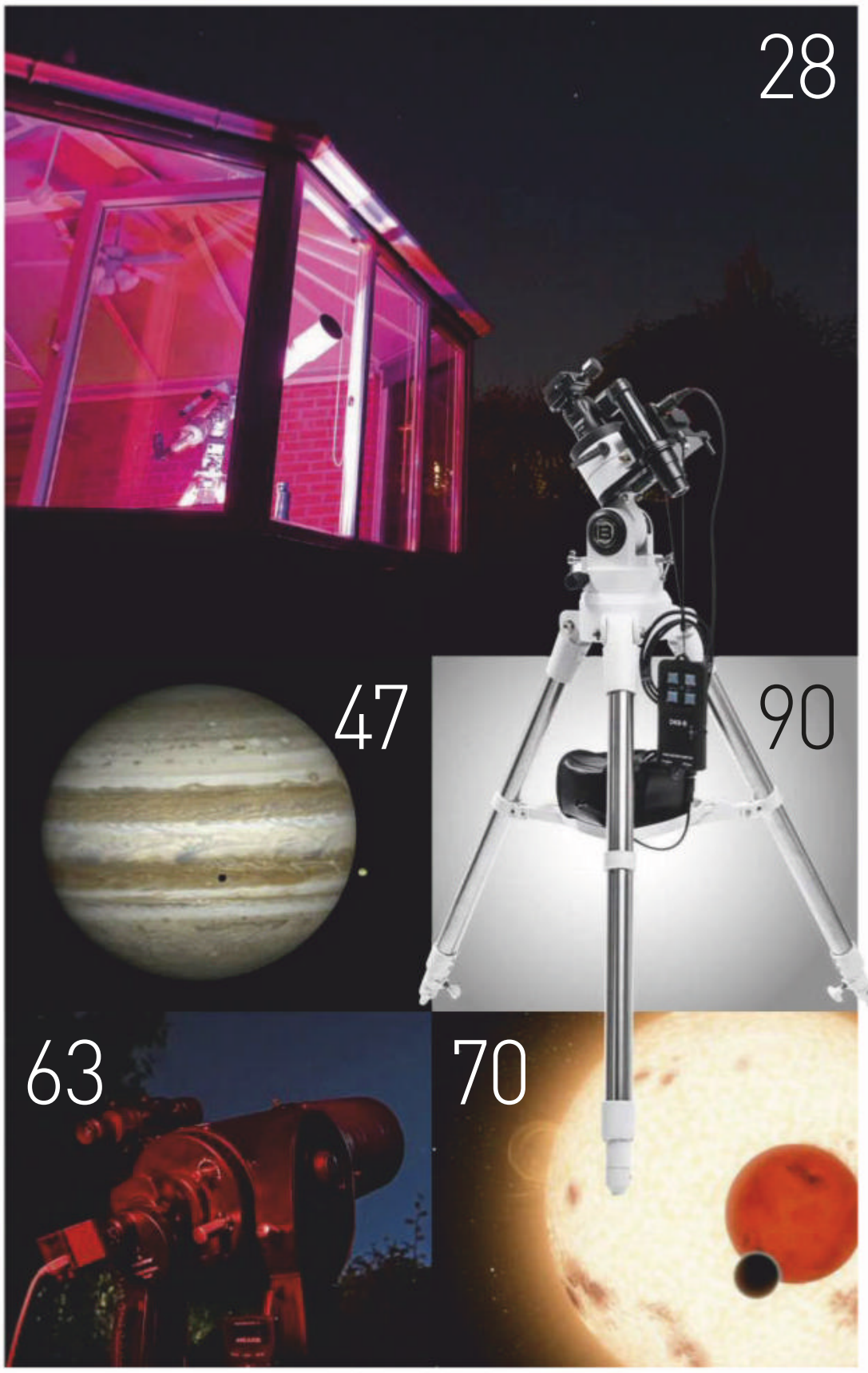
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COVER MAIN IMAGE: XXXXX, THIS PAGE: PETE LAWRENCE X 2, WILL GATER, NASA/JPL-CALTECH/R. HURT, NASA AMES/JPL-CALTECH/T PYLE, WWW.SECRETSTUDIO.NET, NASA/JPL, BBC

New to astronomy?

To get started, check out our guides and glossary at
www.skyatnightmagazine.com/astronomy-for-beginners



This month's contributors

Pippa Goldschmidt

Astronomy writer



A quest for exoplanets – and much more. Pippa reviews Nicholas Mee's *The Cosmic Mystery Tour* on page 94

Tim Jardine

Amateur astronomer



Choosing your first scope needn't be a daunting process. Turn to Tim's guide on page 35 for essential tips

Steve Owens

Dark skies consultant



As dark skies become more sought after, Steve advises how best to find and protect them. See page 60

Elizabeth Pearson

News editor

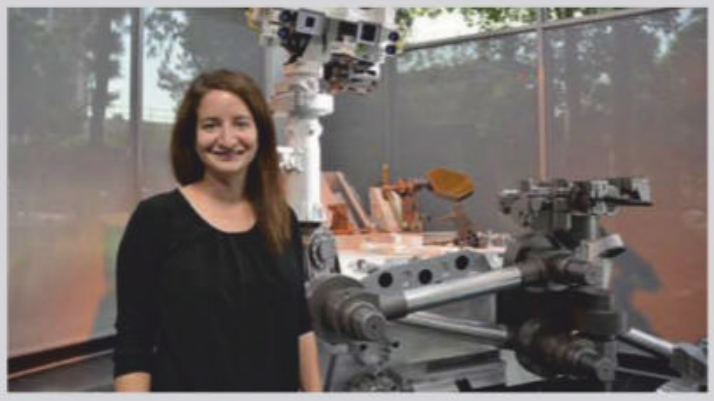


See page 10 for new discoveries about gravity on Mars, and the size of Earth's atmosphere

Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonuscontent**, select April's Bonus Content from the list and enter the authorisation code **XCESX3D** when prompted

April highlights



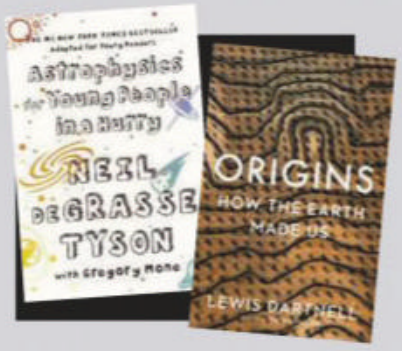
Interview: Opportunity's end

The NASA Opportunity rover's 15-year mission on Mars is complete. Watch our video interview with Abigail Fraeman, the deputy project scientist, who discusses the rover's investigations into Mars's history, and whether the Red Planet could ever have hosted life.



Watch *The Sky at Night:* Cosmology in Crisis?

The team look into the expansion of the Universe, and meet the scientists trying to discover how and why it is happening.



Sample the latest astro audio books

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PLUS: Every month



The virtual planetarium

April's night-sky highlights with Paul Abel and Pete Lawrence





EYE ON THE SKY

ANDREW WHYTE

Reclaim the NIGHT

Switch off your lights on 30 March for Earth Hour 2019 and become part of a worldwide movement to celebrate darkness

ANDREW WHYTE, WEST SUSSEX, AUGUST 2014

Ask any astronomer what frustrates them most about the hobby and light pollution will be high on the list. Whether it's the skygkow from a nearby city or the glare of single bright unit, artificial light limits how many stars we see in the night sky.

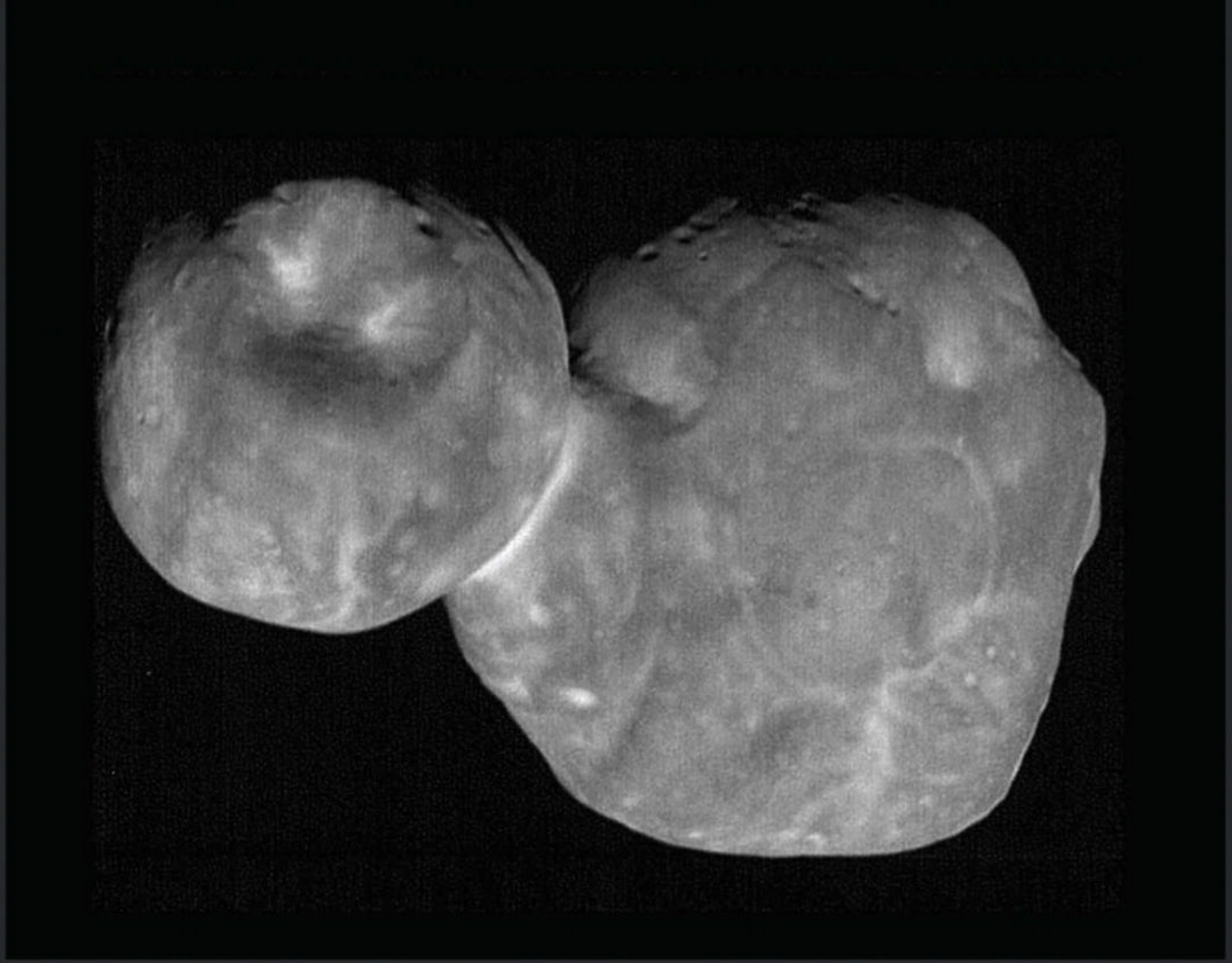
In these three images all taken at f/2.8 and ISO 2500, astrophotographer Andrew Whyte has used different exposures to demonstrate the effects of light pollution. The first picture (top left) was exposed for the illuminated streetlights (0.5") and demonstrates how bright lighting robs the night of starlight. The next (top right) was exposed for the Milky Way (30") with streetlights on; despite stars being visible, they are drowned out by glare.

When the streetlights were switched off at 1am, Andrew captured the scene with another 30-second exposure. The striking difference is visible in the image on the page opposite, where the Milky Way is seen extending down to the rooftops. The three images show clearly the effect that limiting artificial light has on the visibility of the stars.

On 30 March at 2019, people around the world will be switching off their lights from 8.30pm until 9.30pm for Earth Hour; an annual campaign demonstrating the impact of light pollution. Visit **www.earthhour.org** to get involved, and for advice on how you can help protect darkness in your area read this month's Explainer on p60.

More **ONLINE**

A gallery of these and more stunning space images



△ Kuiper Belt close-up

NEW HORIZONS, 1 JANUARY 2019

The New Horizons spacecraft captured this image of Ultima Thule as it flew by the Kuiper Belt object at 50,000 km per hour on New Year's Day 2019. Ultima Thule is about 30km in diameter, its odd shape probably the result of two bodies merging after a collision. The Kuiper Belt is a ring of rocky, icy relics on the edge of the Solar System, and studying it may reveal clues about the formation and evolution of the planets orbiting the Sun.

Testing the optics ▷

SPECULOOS, 25 FEBRUARY 2019

SPECULOOS is the latest addition to ESO's Paranal Observatory in the Chilean Atacama Desert. The observatory's four 1m telescopes will search for exoplanets orbiting stars so follow-up investigations can be made with more powerful telescopes. SPECULOOS has been observing familiar objects to test its capabilities. Here its Ganymede telescope imaged spiral galaxy NGC 6902, located 120 million lightyears from Earth.

ASA/JOHNS HOPKINS APPLIED PHYSICS LABORATORY/SOUTHWEST RESEARCH INSTITUTE/NATIONAL OPTICAL ASTRONOMY OBSERVATORY, ESO, ESO/A MCLEOD ET AL, ESA/HUBBLE & NASA/S. LARSEN ET AL



◁ Nebula in a nearby galaxy

VERY LARGE TELESCOPE, 6 FEBRUARY 2019

Newborn stars glow brightly in colourful nebula LHA 120-N 180B. The region is a stellar nursery that hosts energetic bursts of star formation. It's located in the Large Magellanic Cloud, a satellite galaxy of the Milky Way 160,000 lightyears distant, making it a cosmic neighbour.

▽ Separated at birth?

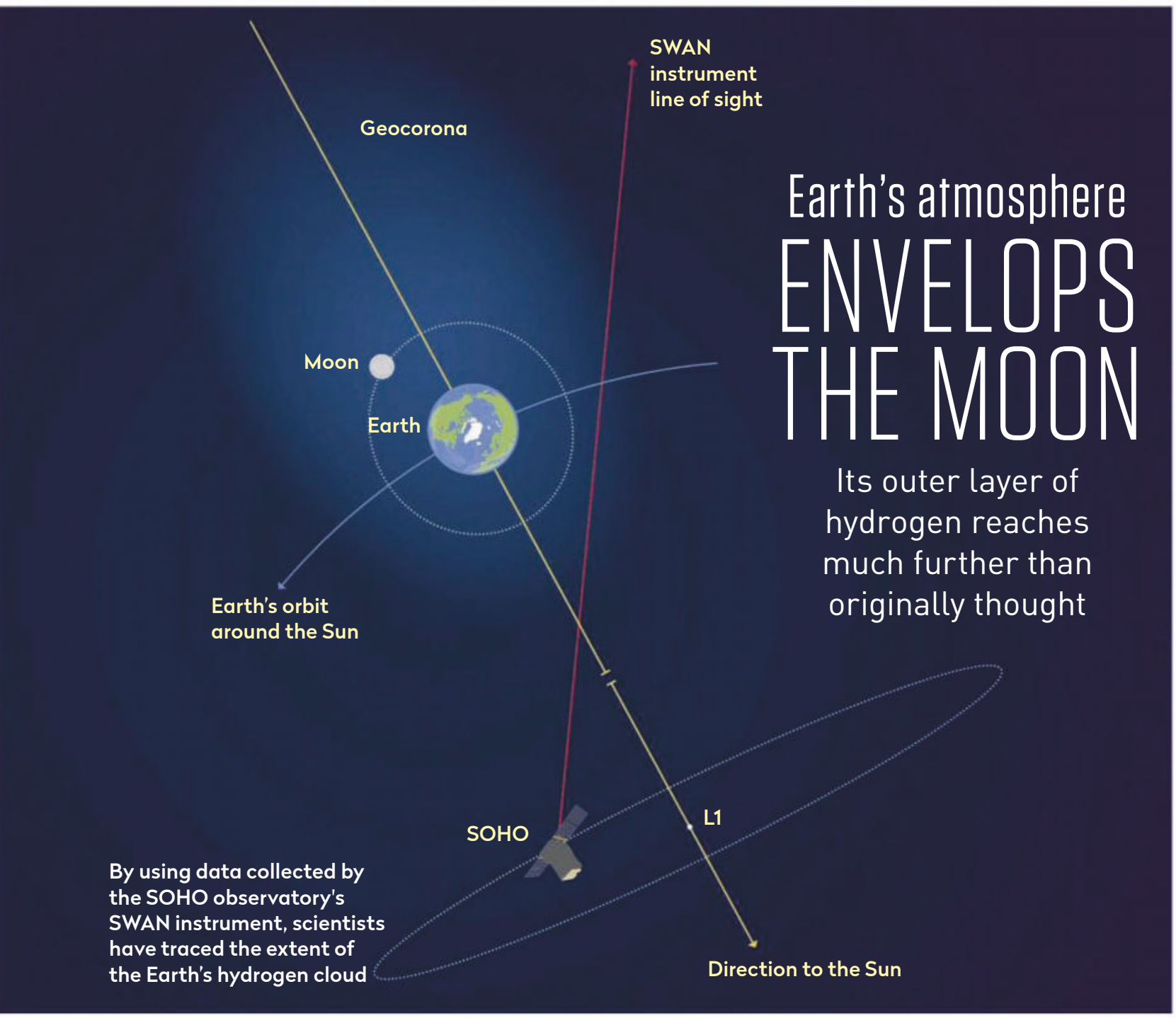
HUBBLE SPACE TELESCOPE, 25 FEBRUARY 2019

Because stars in globular clusters formed around the same time in the early Universe, they should all be roughly the same. But studies of NGC 2419 reveal two populations of red giant stars with different chemical compositions. Unlocking the mystery of whether this globular cluster was formed by other means may reveal clues about the early Universe.



The latest astronomy and space news, written by Elizabeth Pearson

BULLETIN



By using data collected by the SOHO observatory's SWAN instrument, scientists have traced the extent of the Earth's hydrogen cloud

ESA, NASA/JPL-CALTECH, JAXA, JAXA/UNIVERSITY OF TOKYO/KOCHI UNIVERSITY/ RIKKYO UNIVERSITY/NAGOYA UNIVERSITY/CHIBA INSTITUTE OF TECHNOLOGY/MEIJI UNIVERSITY/UNIVERSITY OF AIZU/AIST

Earth's atmosphere ENVELOPS THE MOON

Its outer layer of hydrogen reaches much further than originally thought

Earth's atmosphere is far bigger than we realised, extending out beyond the Moon. The cloud of hydrogen that surrounds our planet, known as the geocorona, reaches out to 630,000km – almost twice the distance to the Moon – according to a new analysis of measurements taken over 20 years ago. To uncover the full extent of the Earth's atmosphere, a team of astronomers examined images of Earth taken by the Solar and Heliospheric Observatory (SOHO) between 1996 and 1998. They looked at a specific wavelength of ultraviolet light, called Lyman-alpha light, which signifies the presence of hydrogen. The size of the cloud has gone unnoticed due to its low density – at the distance of the Moon, you would have to look at five cubic centimetres of space to find just one atom.

The extended atmosphere poses no risks to future space farers, either human or robotic, as levels of ultraviolet radiation from it are minimal, but it could still interfere with space-based observatories.

"Space telescopes observing the sky in ultraviolet wavelengths to study the chemical composition of stars and galaxies would need to take this into account," says Jean-Loup Bertaux, from the French National Centre for Scientific Research, who took part in the investigation.

The discovery could also help in the search for habitable planets beyond Earth. In our own Solar System, finding hydrogen around a planet is an indication that there is water vapour nearer the planet's surface.

"This is especially interesting when looking for planets with potential reservoirs of water beyond our Solar System," says Bertaux.

http://sci.esa.int/soho/



Comment

by Chris Lintott

Old data can tell us new stories. This result uses data from SOHO's youth in the 1990s, but the most famous observations of the geocorona go back further than that.

As part of the Apollo 16 mission, astronauts John Young and Charlie Duke deployed the first telescope on the lunar surface in 1972. It had only a three-inch aperture, but was equipped with a camera that was sensitive to the same ultraviolet wavelenghts that SOHO would look at. The astronauts had to point the telescope by hand – not easy in a spacesuit. Once the film was processed, the results included a shot of the Earth's geocorona glow, a feature we now know extended to engulf the astronauts as they stood on the lunar highlands.

Chris Lintott co-presents *The Sky at Night*



Lost in space: NASA has given up hope of contacting the Mars rover Opportunity

Opportunity mission ends

The rover helped to trace the history of water on the Red Planet

NASA made its last attempt to contact veteran Mars explorer, Opportunity, on 13 February, marking the end of the rover's 15-year mission.

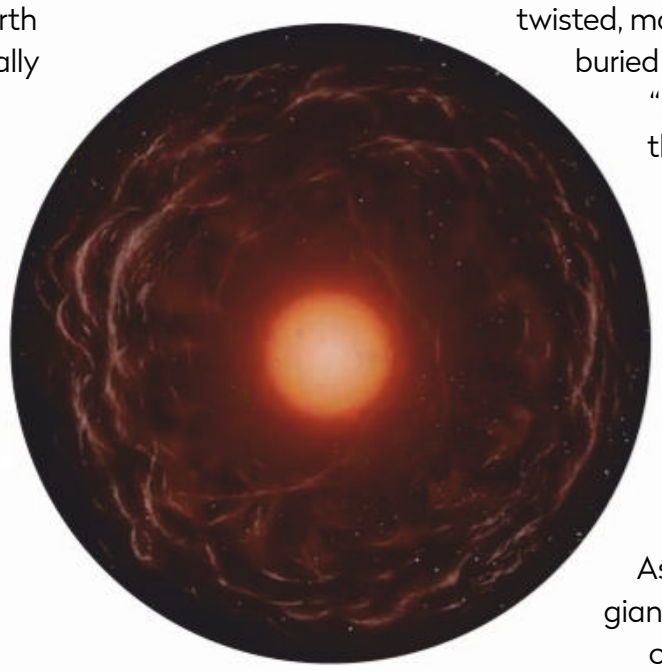
The agency lost contact with the rover on 10 June 2018, when a global dust storm prevented Opportunity from charging its solar panels. NASA hoped the rover would phone home after the storm passed, but after eight months and over 1,000 attempts to re-establish contact, NASA engineers have finally admitted defeat.

Opportunity landed on Mars on 25 January 2004, along with its twin, Spirit. The pair were initially meant to last just 90 days, hunting out signs of past water on the Red Planet. "From the outset, Opportunity delivered on our search for evidence regarding water," says Steve Squyres, principal investigator of the rovers' science payload at Cornell University.

Superwinds suggest secondary stars

Superwinds from red giants, which appear to eject as much as 100 Earth masses a year, might actually be the effect of a second star orbiting the giant, according to a new study.

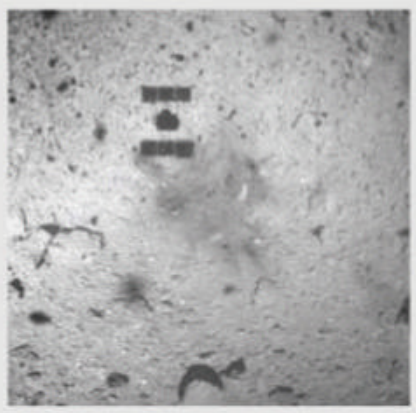
Most red giants eject material at a prodigious rate, but so far 12 have been found hurling out over 10 times the amount that is normally seen. It's thought these superwinds last between 100 to 2,000 years. Using the Atacama Large Millimetre/ submillimetre Array in Chile, the team studied the gas disc around one of these red giants and found it was being twisted, most likely by a second star buried in the gas.



▲ **An artist's impression of the gas disc around a red giant. New research suggests the gas is been twisted by a second star**

"It only seemed as though they were losing a lot of mass because there's an area between the two stars where the stellar wind is much more concentrated due to the gravity of the second star," says Leen Decin from the KU Leuven Institute of Astronomy. "These red giants don't lose the equivalent of 100 Earths per year, but rather 10 of them, just like regular red giants." **www.kuleuven.be**

NEWS IN BRIEF



Hayabusa 2 touches down

Japanese asteroid investigator, Hayabusa 2, touched down onto Ryugu for the first time on 21 February. The spacecraft collected a sample of the asteroid by firing a projectile into the surface and retreiving the particles kicked up. Hayabusa 2 will attempt another two touchdowns before returning to Earth with sample material in late 2019.

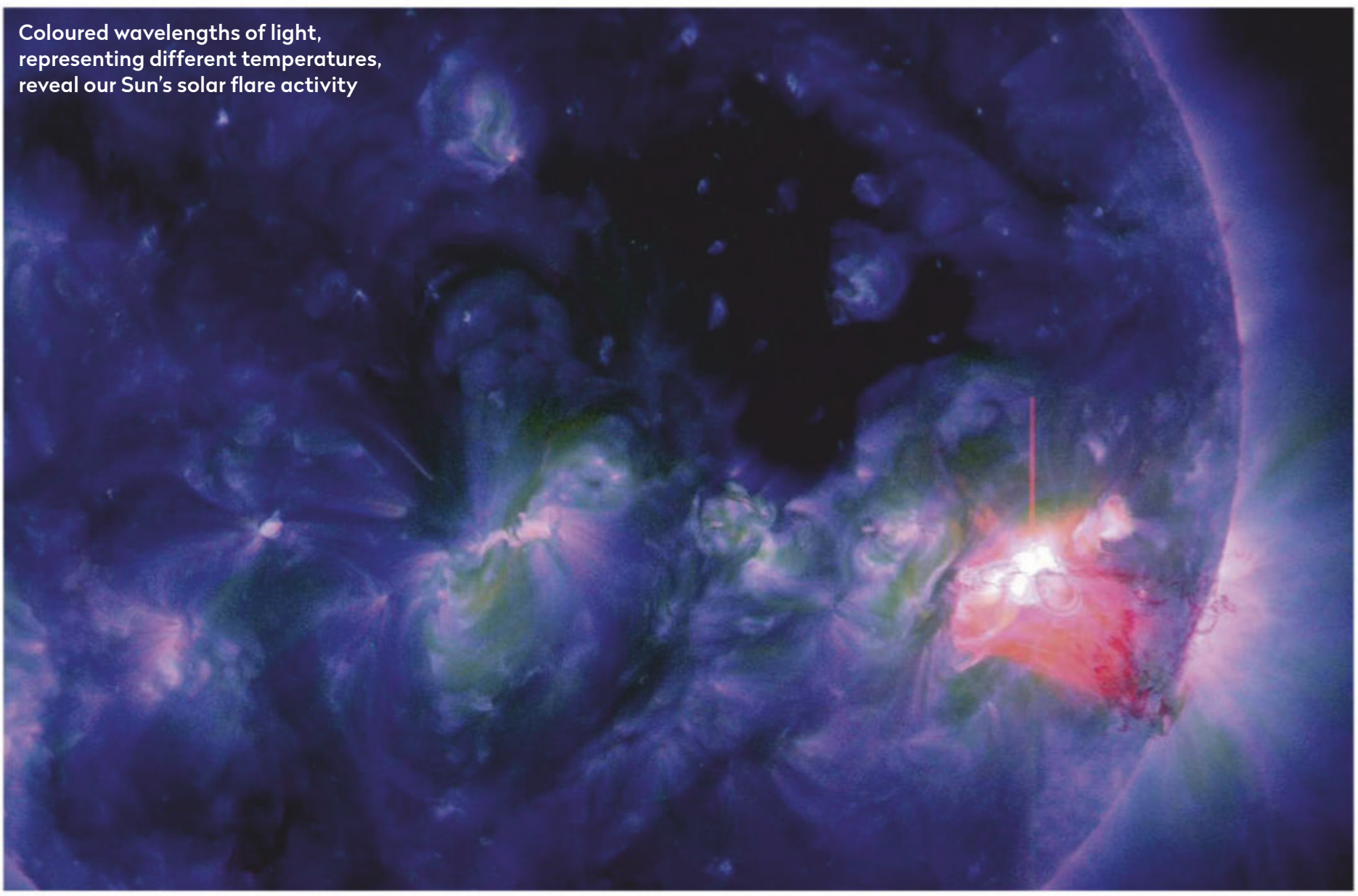
Chip off the old Neptune

One of Neptune's tiniest moons, 32km-wide Hippocamp, was chipped off fellow moon Proteus, according to a recent study of Voyager images. Hippocamp was discovered in 2013, trailing 12,000km behind the larger moon. Its origin was uncovered when astronomers noticed an impact crater on Proteus large enough to have created Hippocamp.

SpaceX test crew capsule

SpaceX made its first test launch of its Crew Dragon capsule, which will one day take astronauts to and from the International Space Station (ISS), on 2 March 2019. It successfully docked with the ISS but at time of writing had yet to undertake the riskiest part of its mission – atmospheric re-entry.

BULLETIN



Coloured wavelengths of light, representing different temperatures, reveal our Sun's solar flare activity

NASA/SDO, KO ARIMATSU, NASA/JPL-CALTECH/MSSS

Most intense stellar flare ever spotted

A giant superflare gives vital clues about the formation of a new star

A stellar flare 10 billion times more powerful than those produced by our Sun has been spotted erupting from a young star in the Orion Nebula. The flare only lasted a few hours, but the James Clerk Maxwell Telescope (JCMT) managed to capture it.

Flares are created by the interaction between a star's intense magnetic field and plasma – the charged particles which the star is made up of. Plasma gets trapped along the magnetic field lines, until a disruption in the field makes them snap and hurl out plasma at nearly the speed of light.

Solar flares, created by our own Sun, are one of the most powerful events to occur within the Solar System, but they are dwarfed by those seen coming from this young star. It's thought the star's youth might be the cause of the flare's intensity. The star is still gathering gas from its surroundings as it grows, which is then funnelled onto the star by its magnetic field, amplifying the effect of the eruption.

"Observing flares around the youngest stars is new territory and it is giving us key insights into the physical conditions of these systems. Using the JCMT, we study the birth of nearby stars as a means of understanding the history of our very own Solar System," says Steve Mairs, a support astronomer at the JCMT.

Studying flares is also vital for understanding the current Solar System – and particularly us humans within it – as the outbursts are an important component of space weather. The rush of particles and radiation from a solar flare are extremely harmful to life, and would cause significant damage if they reached the surface. Thankfully, Earth's magnetic field and atmosphere mean passing flares are kept at bay – though satellites and astronauts beyond these protections must sometimes take measures against incoming flares.

However, if the Sun released flares as powerful as the star in Orion, those protections would not be enough to save us. Fortunately, these flares appear to be simply the growing pains of a young star, and so we shouldn't fear a similar superflare erupting from the Sun any time soon.

https://www.eaobservatory.org/jcmt/

Planetary missing link uncovered

The 1km-sized space rock bridges the gap of planetary evolution



▲ An impression of the space rock discovered in the Kuiper Belt

The missing link in planetary evolution has been found using off-the-shelf telescopes, it was announced in February.

The new find validates theories that the rocky bodies of the early Solar System grew slowly to kilometre sizes, before merging to form planets. Until this discovery, astronomers theorised that there should be many of these kilometre-sized objects in the Solar System.

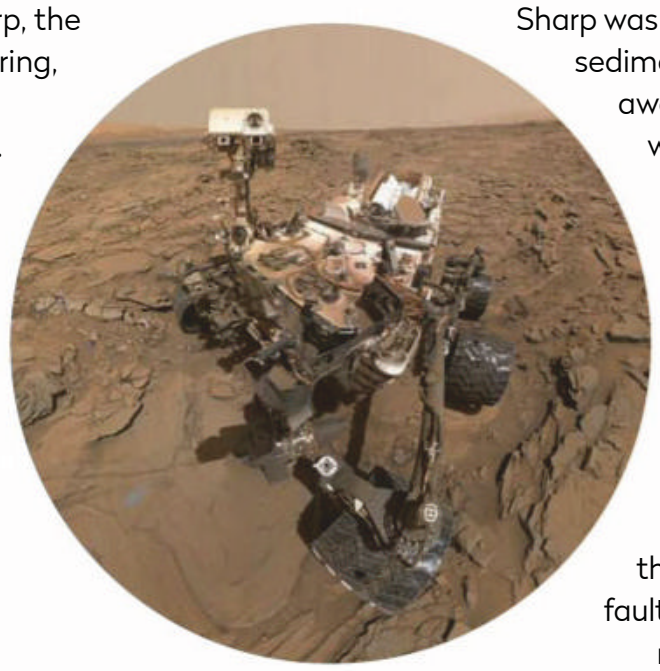
To hunt for them, a team of astronomers set up two 28cm telescopes, monitoring 2,000 stars for the temporary dimming caused by an object passing in front. After 60 hours of observation, they discovered an object 1.3km in radius.

"Our team had less than 0.3 per cent of the budget of large international projects. Yet we still managed to make a discovery that is impossible for the big projects," says Ko Arimatsu from the National Astronomical Observatory in Japan, who led the study. **www.nao.ac.jp**

Mars's gravity measured by accident

The Curiosity rover has measured the gravity of Mount Sharp, the region it is currently exploring, for almost five years – completely by accident.

The Curiosity team recently discovered that the rover's accelerometer readings can be used to measure fluctuations in the planet's gravity, caused by changes in rock density under the surface. Using data from October 2012 to June 2017, the team found that the rock beneath Mount Sharp is less dense than expected.



▲ A self-portrait of NASA's Curiosity Mars rover, taken in 2016 on the rugged Naukluft Plateau of lower Mount Sharp

Previously, geologists thought that Mount Sharp was once buried under sediment which then eroded away, but the sediment's weight would have pushed down on the rock, making it denser. Curiosity's findings suggest there was less sediment than predicted early on in the feature's geological history.

The find comes shortly after news Curiosity is on the mend after a computer fault. The rover entered safe mode during a reset on 15 February, but has booted up 30 times since. **https://mars.nasa.gov/msl/**

NEWS IN BRIEF



Ancient dwarf has a ring

The oldest white dwarf with rings ever seen was unexpectedly discovered by citizen science project Backyard Worlds: Planet 9, a venture which usually looks for strange objects within our own Solar System. The star's 3-billion-year age calls into question how these rings form, as most theories state they should only last 100 million years or so.

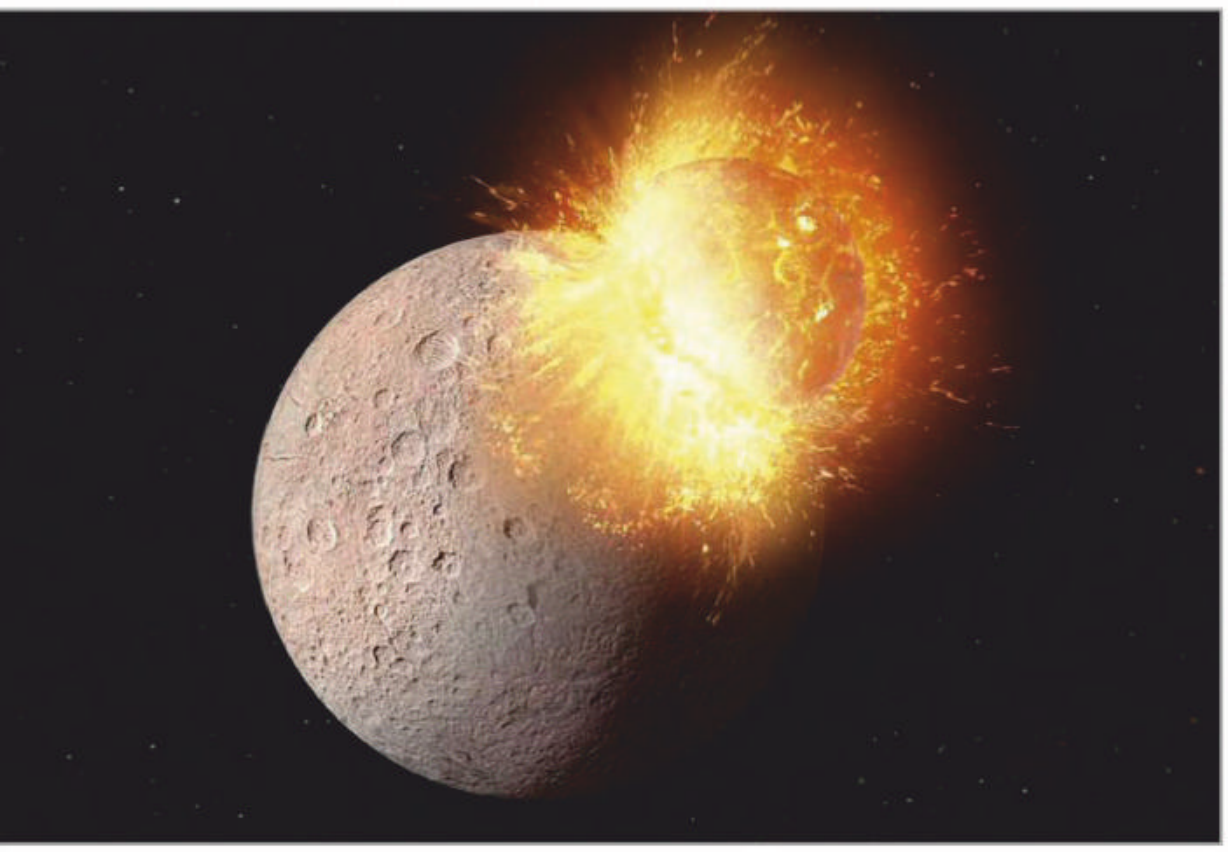
Distant Solar System object found

The most distant object ever seen within our Solar System has been found 140 times further from the Sun than Earth. The object, nicknamed FarFarOut, was uncovered by astronomer Scott Shepherd from Carnegie Institution for Science while he was snowed in by February's polar vortex.

First commercial lunar lander underway

The first Moon lander from a non-government agency, Beresheet, launched towards the Moon on 21 February, and is due to touch down on 11 April. The lander's creators, Israeli company SpaceIL, were initially competing for the Google Lunar X Prize, but continued the mission even after the competition ended in March 2018 with no winner.

CUTTING EDGE



SCIENCE PHOTO LIBRARY/ALAMY STOCK PHOTO, ISTOCK

◄ Kepler-107c has a dense core, indicating that a huge planetary collision could have stripped its outer layers

Mercury's twin found in exoplanet system

Does the formation of Kepler-107c mirror that of our innermost planet?

We've explored in previous 'Cutting Edge' columns the quirky nature of the Solar System's innermost planet, Mercury. Despite being much smaller than Earth, Mercury is notably dense. Planetary scientists estimate that its heavy iron core must make up around two-thirds of the entire planet; far larger, proportionally, than that of any of the other rocky planets. The leading theory for how Mercury got so dense is that it originally formed with a larger fraction of lighter, silicate mantle, but that much of this was blasted off by a colossal planetary collision.

So far, there has been no clear evidence of such world-altering collisions in extrasolar planetary systems. That is until now. Aldo Bonomo, at the INAF Astrophysical Observatory of Turin, Italy, and his colleagues were studying an exoplanetary system discovered in 2014 by the Kepler Space Telescope. The Kepler-107 system is made up of four known planets, orbiting around their Sun-like star about 1,700 lightyears away. The planets have orbital periods between 3.2 and 14.8 days, fitting into a pattern of orbital resonances that indicates these planets originally formed further from their sun, before migrating inwards and becoming locked into these resonances. (This is similar to the 4:2:1 orbital resonance exhibited by Jupiter's large moons Io, Europa and Ganymede, respectively).

Kepler discovered these planets using the transit method, but Bonomo and his colleagues wanted to find the mass and therefore density of these planets. So they observed the star with the high-resolution HARPS-N spectrograph at the Telescopio Nazionale Galileo in La Palma to measure cyclical shifts in its radial velocity caused by the gravitational tugs of these orbiting planets. They found that although the two inner planets, Kepler-107b and c, have nearly identically radii (both 1.5–1.6 Earths) the second planet is almost twice as dense as the innermost. This means, just like Mercury, that Kepler-107c must have a huge iron core; making up about 70 per cent of its total mass.

"Huge planetary collisions are thought to be behind the characteristics of several planets in our Solar System"

One possible explanation for the stripping-away of the planet's outer layers, leaving behind the denser iron core, is it having been baked by extreme X-ray and ultraviolet radiation early in the star's lifetime. But, as Bonomo and his colleagues point out, such a stellar influence would have affected the first planet even more, and Kepler-107b isn't particularly dense. Thus, he concludes, Kepler-107c's dense nature must be due to a huge collision. Such an impact would likely destabilise the current resonance pattern of the four planets' orbits, and so it must have occurred early in the system's evolution, before the planets had finished migrating.

Huge planetary collisions are thought to be behind the characteristics of several planets in our Solar System – Mercury's dense composition, the origin of Earth's Moon, and the high orbital obliquity of Uranus – and now it seems that they may also be a common feature of planetary systems across the Galaxy.



Prof Lewis Dartnell is an astrobiologist at the University of Westminster and author of *Origins: How the Earth Made Us* (geni.us/origins)

Lewis Dartnell was reading... *A giant impact as the likely origin of different twins in the Kepler-107 exoplanet system* by Aldo S Bonomo. **Read it online at arxiv.org/abs/1902.01316**

Fluffy asteroid or alien spacecraft?

What 'Oumuamua's unexpected change of direction tells us about our interstellar visitor



Prof Chris Lintott is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also director of the Zooniverse project

The visit of 'Oumuamua, the first object ever observed passing through the Solar System on an interstellar trajectory, is still causing excitement nearly 18 months after discovery. Much of the fuss is because 'Oumuamua didn't behave like it is solely under the influence of gravity, an effect which has led Avi Loeb, a Harvard professor, to suggest that it might be an alien spacecraft.

Avi may be disappointed by this month's paper, from Amaya Moro-Martín at Baltimore's Space Telescope Science Institute, who sets out to explain the observed behaviour. It's actually not that unusual for small bodies to behave like this – as icy comets swing past the Sun, the effect of our star's heat is to cause outgassing, creating the spectacular tails we see. Such activity acts rather like a small jet engine, pushing the comet and altering its orbit.

The trouble is that 'Oumuamua showed no sign of cometary activity, despite an intensive search for the carbon dioxide that appears in comet jets with the Spitzer space telescope, and there was certainly not enough to account for the observed changes in its orbit. One option is that 'Oumuamua, being an unusual object, may have produced jets of different material, invisible in these Spitzer observations. It wouldn't have to be anything too weird, water would do, but it would make 'Oumuamua unusual. What's needed is an explanation that doesn't require this first interstellar wanderer to be anything too odd.

That's what Moro-Martín thinks she's got. The solution is actually the same as that provided by Avi Loeb and his collaborators, in which all that's happening is that the radiation pressure – the push from the Sun's light – is significant. In Loeb's case, he argues for a very broad, flat structure – the kind of solar sail aliens in science fiction use to get around. In Moro-Martín's paper, the effect of radiation pressure is made more important by adding a fractal structure.

Fractals – objects with structure on all scales – exist everywhere. An classic example is an island like Great Britain – measure its length with smaller and smaller rulers and you get bigger and bigger answers! In the context of an object like 'Oumuamua, instead of a solid surface you would have a highly porous surface. We know interplanetary dust particles are fractal; if they assemble gently it's not too much of a stretch to imagine the whole body might be similarly structured.

How does this help? If 'Oumuamua does have this 'fluffy' structure it would be spectacularly lighter than we might otherwise assume for a body of this size, and so the radiation pressure from the Sun would have a bigger impact, exactly as observed. A simple tweak to 'Oumuamua's structure solves the problem, though it leaves open the question of how such a fractal body, unlike the comets in our own Solar System visited by spacecraft, might form.

"What's needed is an explanation that doesn't require this first interstellar wanderer to be anything odd"



An artist's impression of 'Oumuamua. Its gravity defying movements could be explained by a highly porous structure

Chris Lintott was reading... *Could 1I/'Oumuamua be an icy fractal aggregate ejected from a protoplanetary disk? A fluffy radiation-pressure-driven scenario* by Amaya Moro-Martín. **Read it online at arxiv.org/abs/1902.04100**

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT



Astronomer Simon Bennett (left) with *Sky at Night* presenter Pete Lawrence, during the filming of an episode in London's Regent's Park

BBC, NASA/JPL, NASA

February's *Sky at Night* programme joined a London astronomy society to observe the night skies. Society co-founder **Simon Bennett** tells us more

A *Sky at Night* production team is an unusual set of guests to welcome to a monthly society meeting, but that's exactly what happened at our Baker Street Irregular Astronomers' January get-together. Presenter Pete Lawrence and a camera crew of two arrived to film astronomers in action in central London, observing the scale of the Universe.

The clouds cooperated and although it was exceptionally cold – ice formed on telescopes and the dew froze – there was no wind. A classic, lively BSIA meeting ensued: we imaged distant galaxies through light pollution filters, sought out Cepheid variables, and were on hand to answer the many questions from newcomers and show them the view through the scopes. *The Sky at Night* team came away with exactly the footage they wanted.

This was a fitting way to mark our 100th meeting. We have had instances of meetings going 'viral' with vast numbers showing up. Not wanting this to happen for the 100th meeting, we didn't announce our surprise guests on social media beforehand.

It's all a far cry from the Baker Street Irregular Astronomers' first meeting back in June 2010. Back then, a group of around 25 people gathered to set up their telescopes outside in the park and enjoy a warm summer evening with clearing skies.

One hundred meetings later, the Baker Street Irregular Astronomers has become a fixture in central London. Indeed, it is the only group allowed to use what is a locked, high-security park after hours. The proximity of embassies and ambassadors' residences in the streets surrounding Regent's Park means we must tread a tightrope of rules and regulations, but its worth it to be able to take advantage of the stunning location that it offers.

Capital benefits

Our venue, The Hub, sits on a grassy mount close to the centre of 166 hectares of parkland. There's a paved circular terrace around it, and from the centre of the Park, the trees block out much of the glare from the city's bright lights. The café stays open for us in the evenings, providing a place of refuge as well as welcome refreshments.



Simon Bennett is co-founder of the Baker Street Irregular Astronomers and a lifelong amateur astronomer

The Baker Street Irregular Astronomer's are a relaxed and informal bunch. A committee of five and a pack of regular 'Irregulars' entertain and engage the many newcomers to each meeting, where numbers usually hover around the 100 mark. We get people from all walks of life, all ages and backgrounds. We've done this month in, month out, since the beginning and over that time have dealt with all manner of questions regarding the nature of the Universe, choosing a telescope and the scale of the heavens above us.

Unlike most astronomical societies, we don't require formal membership or currently charge any fees for joining. We rely instead on donations, which can be regular or one-off. Everyone is free to come along to meetings, to find out why we do what we do, and ask for advice. We aren't going to let a little light pollution stop us from bringing astronomy to central London, where millions of potential stargazers go about their lives unaware of the stunning natural beauty that hangs above their heads, far above the city skyline.

Find out about Baker Street Irregular Astronomers' meetings on Facebook and Twitter and sign up to receive monthly email newsletters at www.bakerstreetastro.org.uk

Looking back
The Sky at Night

24 April 1974



On 24 April 1974's episode of *The Sky at Night*, Patrick Moore was looking towards Mercury. The previous month, on 29 March, humanity had been given its first close-up view of the planet, thanks to NASA's Mariner 10 spacecraft.

Over the next year, Mariner visited Mercury another three times. Due to the timing of the orbits, the same side of the planet was in shadow, so only 40 to 45 per cent of the surface could be photographed. But these images were enough to reveal what kind of world Mercury was.



▲ **A mosaic of images taken by Mariner 10 revealed the cratered surface of Mercury**

Mariner 10 revealed the planet had no atmosphere and was just as cratered as the Moon. This indicated that any volcanic or other geological activity which might have refreshed the surface had ceased long ago.

Unexpectedly, Mariner found that Mercury had a magnetic field. These fields are created by the motion of a planet's molten iron core, but Mercury is so small that it's centre should have solidified long ago. Even though the field's strength is barely one per cent that of Earth's, the fact that it exists at all is something of a surprise.



Marsquake!

Little is known about what's going on below the surface of Mars, but answers may soon be coming via NASA's latest mission: InSight. It aims to peer into Mars's interior, learn about how the Red Planet formed and why it's different from Earth. *The Sky at Night* brings us the latest news from the mission and bids farewell to Opportunity rover, which transformed our view of Mars.

BBC Four, **14 April,** 10pm (first repeat BBC Four, **18 April,** 7.30pm)
Check www.bbc.co.uk/skyatnight for subsequent repeat times



▲ **InSight will drill below the surface of Mars to reveal the secrets of the Red Planet**

INTERACTIVE

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This month's top prize: four Philip's books



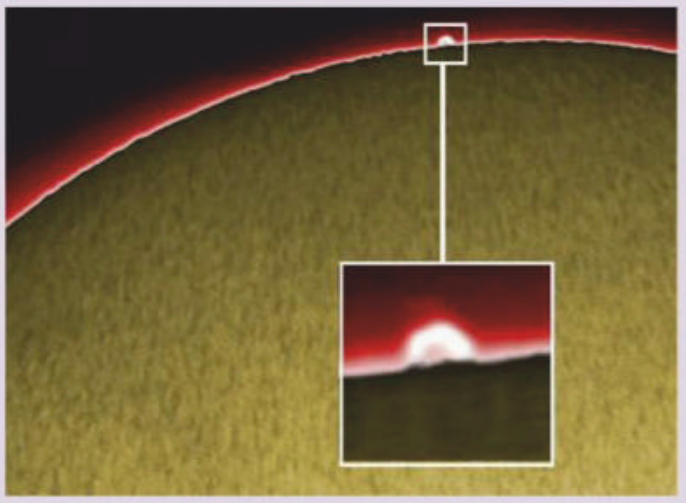
PHILIP'S

The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Mark Thompson's *Stargazing with Mark Thompson* and Heather Couper and Nigel Henbest's *2019 Stargazing*.

Winner's details will be passed on to Octopus Publishing to fulfil the prize

MESSAGE OF THE MONTH

Uncovering a solar mystery



▲ **Roger's puzzling solar image was taken with a Lunt LS35THa telescope, Bresser MikrOkular Full HD eyepiece camera and a 2x Barlow lens**

I came across this strange solar anomaly after examining one of my windowsill-based solar hydrogen-alpha observations from early February. It was present on all 200 frames of my AVI movie. I cross-referenced the data I'd captured with the National Solar Observatory's Global Oscillation Network Group (https://gong.nso.edu) for the same time and there it was, but only on one frame.

The feature is strange for various reasons: one, it's very short-lived; two, it has a curious bubble-like shape; and three, it's at an unusual latitude – you don't normally see H-alpha prominences so near the solar pole (north is at the top in the image).

I don't know what this anomaly was but I'm interested to find out. Do any readers have an idea of what it might be?

Roger Samworth, Nuneaton

What a fascinating observation, Roger. This looks to be an active flare caught in a rare loop phase. Well done for spotting it! – *Ed*

Tweets



Nick Williams
@nick5170 • 19 Feb
The clouds cleared to reveal the #SuperSnowMoon over NE London this evening @skyatnightmag @BBCStargazing @VirtualAstro @SkyandTelescope



STEVE RICHARDS



A rope or a claw?

Ten days after New Moon I was panning down the lunar terminator with my 8-inch Sky-Watcher and happened to observe the Montes Riphaeus mountain range, near Crater Euclides. I know light on the lunar surface can create effects such as the Lunar X and Lunar V, but what surprised me on this occasion was that it made the mountain range resemble an unravelling braided rope. On closer observation it struck me that it looked just like a chicken's foot. Other readers might be interested in checking out this region and reporting back: if others witness this phenomenon, may I propose naming it the Lunar Claw?

John Consadine, Norfolk

Patience pays off

I read Robert Stewart's letter in the January issue about his frustration at being unable to see the Andromeda Galaxy with the naked eye, and wanted to say I empathise with his predicament. It took me almost four weeks of trying to see Andromeda. Aside from the cloud cover I had to contend with, I also live in a city and have a lamppost just across the

street from me. I didn't see Andromeda with my naked eyes (I'm also 'the better side of 60') but I was able to glimpse it through a pair of binoculars. Knowing where to look helps, but patience is the key. I was thrilled when I finally made it out. Keep trying – with or without observing equipment – it is there.
Gary Brown, via email

Space spud

In response to the lead story in February's 'Bulletin' ('New Year flyby for New Horizons', page 10) I thought you might be intrigued to see this photo. Ultima Thule's amazing shape is perfectly echoed by a potato I grew (and managed to scar with my spade). It is even the same size as the photograph in the magazine.
John Hitchens, Petworth, Sussex ▸



ON FACEBOOK

WE ASKED: What's your advice for people buying their first scope? (see our guide on page 35)

Gary Anderson
Get as large a Go-To scope as funds will allow. You'll find things are easy to find and you'll know what you are looking at. The Sky-Watcher Star Discovery 150p is a great starter scope.

Daniel Rayner
Don't buy a telescope if it's being sold for its magnifying power. It's the size of the lens or mirror that matters: at least 3-inch for a refractor and at least 6-inch for a reflector.

Andrew Gray
Have a look through some first. What you can see through even an expensive scope is often underwhelming. You can often get just as good views with binoculars and a deck chair.

Stuart FR
The best scope is the one you'll actually use. If it's too time-consuming to set up or complicated to learn, you'll find excuses not to get it out.

Jonathen David Harty
Join a local astronomy society. You can often have a look through different types of scopes to see what suits you.

Gillian Rushforth
Think what you'd like to see with it and look at your viewing circumstances (could you house a big scope?) and think whether you would need a portable one or one to use at home to view.

Vincent Caddell
Join a local group and ask questions. Learn the rhythm of the stars and planets with the naked eye, master it, then get a good Dobsonian like a 200P.

Mick Cassidy
Research, research, research... then after all that buy a Dobsonian. The best scope to start with in regards to value for money is an 8-inch model.

Bradley Swift
Buy a pair of binoculars first. At least 10 x 50s: any bigger than this and you will need a tripod to hold them steady for a sharp image. Download Stellarium, it's free planetarium software. You can find night sky objects visible from your location.

SCOPE DOCTOR



Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I have a Meade LX10 telscope tube. Is it possible to attach this to a Sky-Watcher HEQ5 mount to make a Go-To system?

NIGEL BELL



▲ **If you apply packaging felt to a set of oversized tube rings this will help protect your LX10 scope tube**

The Meade LX10 is a fork-mounted Schmidt-Cassegrain telescope (SCT) with an 8-inch aperture. Although motorised, the LX10 fork mount doesn't have Go-To slewing features.

You can do this conversion by first taking the telescope off the fork mount. Remove the three mounting screws on each side, which hold the mounting plates for the fork arms, and then very carefully slide the tube out. You then have the choice of either installing a Vixen-style dovetail bar and radius blocks on the telescope tube, or using tube rings and a dovetail bar. Although the finished appearance may be superior, the radius blocks are a much riskier proposition as the tube would need to be drilled and tapped and we really wouldn't recommend this.

The LX10's optics are pretty good and if your existing telescope is in good condition you can obtain a set of oversized tube rings and apply some packing foam or felt (as pictured) to suit.

Steve's top tip

Why do I need a sturdy mount and tripod?

It is amazing how simply touching the focus knobs on a telescope can really unsettle the view just when you need it all to stay perfectly still. Wind buffeting can also make the telescope visibly shake, while the magnification from the telescope's optics will only amplify this movement.

A sturdy mount and tripod will, therefore, make a huge difference to the quality of your observations by helping to dampen down unwanted movement quickly.

You can make some improvement to the stability of a lighter duty tripod by suspending a substantial weight underneath it, attached to the underside of the tripod's head.

Steve Richards is a keen astro imager and an astronomy equipment expert

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Connection theory

▸ I watched with great interest the close flyby of Ultima Thule, and have been fascinated by the creation of its strange shape and especially the white seam between the two lobes, joining them. I've been theorising about how this seam came about and think that the two icy lobes of Ultima Thule collided very slowly, but with enough frictional force to melt the mutual contact point. The melted ice between the two parts then froze to leave the white seam on view. I cannot see any other way the two bodies might be sealed together as observed. The scientists in the NASA observational room partially guessed at the connection but I feel they missed the obvious. I hope my personal view is of interest and may be confirmed soon by the scientific team's detailed studies.

JR Hicken, via email

Tweets



Steve
@aboveeg • 20 Feb
Wednesday morning Full Moon setting....@AboutEG @BBCSussex @VisitEG @EastGrinsteadLi @egcouncil @MSDCnews @midsussex_times @MeridianFM @skyatnightmag #Sussex #EastGrinstead #Moon #Fullmoon #SuperMoon



Eclipse endeavours

Jonathan Powell's tale of cloud ruining the 1999 solar eclipse ('Tales from the eyepiece', March) is all too familiar. I too was in Cornwall on 11 August that year in the hope of witnessing the same event and watched as the clouds rolled in. Frustrated as I was, I felt even sorrier for the man in the camper van next to mine who'd built a telescope specifically for the event, with un-silvered mirrors and other light-reducing features. Luckily – and I suspect this is true of many '1999ers' – I got to Wyoming in 2017 and had a cloudless view of the most recent solar eclipse as it passed over the US. I'm now saving hard to get out to Mexico for 2024's event and for what will have to be the most spectacular setting of all for a solar eclipse – Egypt's Valley of the Kings in 2027.

Harold Mead, Taunton

SOCIETY IN FOCUS



Wednesday 13 February saw the fifth talk in our season of winter lectures at Salford Astronomical Society. A good crowd gathered at Swinton Gateway, Salford to hear Rod Hine talk about the American astronomer Edward Emerson Barnard (1857–1923). Rod is a member of Bradford Astronomical Society who studied physics at the University of Cambridge before going on to work as an engineer. He has been a keen amateur astronomer for many years and has built up a repertoire of talks on various subjects.

The event included a presentation with slides on the life and work of Barnard, starting with his work in photography, before moving onto astronomy and astrophotography, and his time at the Lick and Yerkes observatories in the US. Barnard made some of his greatest finds there, such as gegenschein in 1887 and his discovery of Jupiter's fifth moon Amalthea on 9 September 1897.

This was followed by a barrage of questions from society members about Barnard's other discoveries, such as the famous Barnard's Loop and Barnard's Star, and other topics like dark nebulosity, which Rod keenly answered. The society members felt that Rod was certainly an accomplished speaker and are keen to hear from him again.

In other news, the society is all set for free public observing nights at our observatory, following a renovation to the scope and facility. Our observatory at Chaseley Fields houses a large 18.5-inch Newtonian reflector on an equatorial tracking fork mount and was opened in 1971 by Sir Patrick Moore.

Gary Yule, Director and Curator of Instruments at Salford Observatory. www.salfordastro.org.uk

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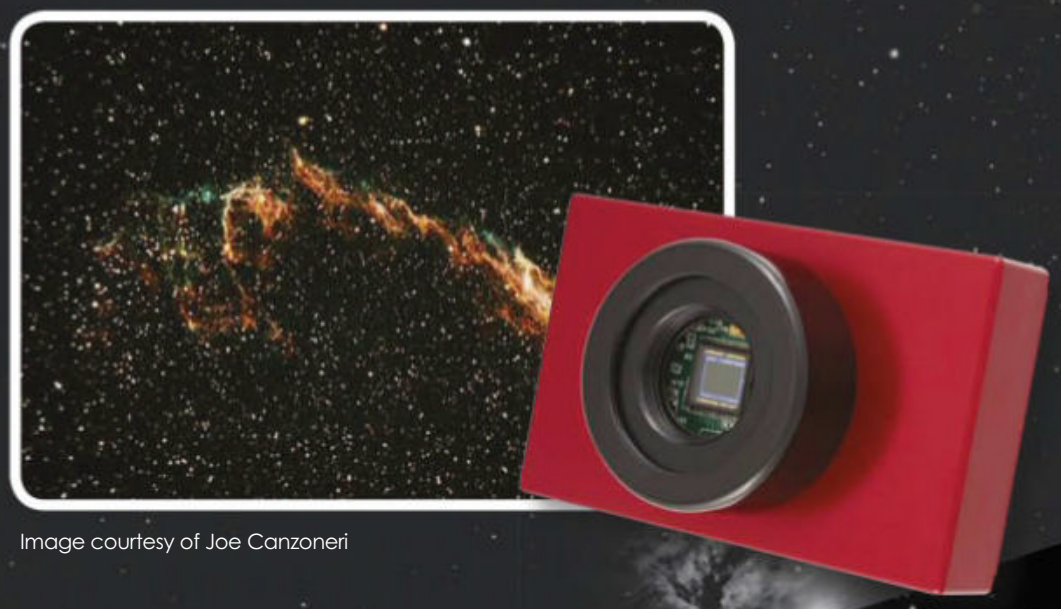


Image courtesy of Joe Canzoneri

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Entry level

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Atik 460EX
Mid range



Image courtesy of George Chatzifrantzis

The Atik 460EX is renowned for its perfect balance of sensitivity and resolution. It utilises a Sony ICX694, which is the sensor of choice for astronomers looking for the highest-quality data. Its efficiency and generous sky coverage make the 460EX one of the most versatile astrophotography cameras around, ideal for a large range of telescopes.

Atik 16200
Large Format

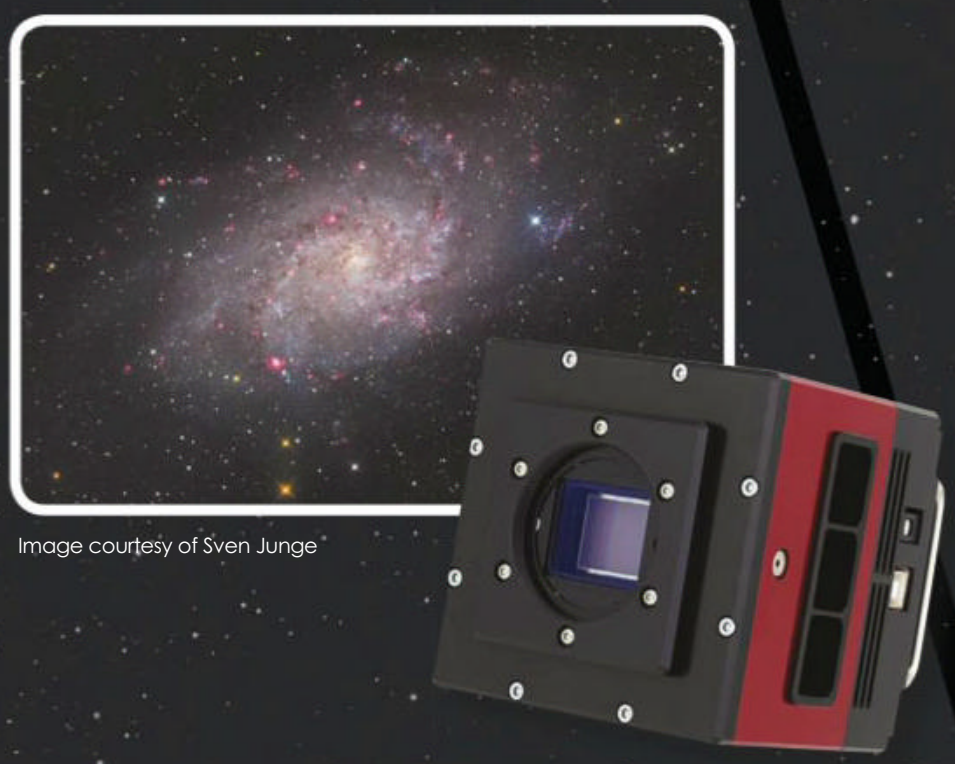


Image courtesy of Sven Junge

The Atik 16200 boasts a sensor specifically designed for astronomy and having a generous 35mm diagonal. The 16million, 6µm pixel sensor can be freely binned so offers a huge amount of flexibility for both wide field and long focal length imaging. Argon purging, deep cooling and a mechanical shutter make this a camera for professionals and amateurs alike. The Atik 16200 is the camera capable of taking your imaging to the next level.

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Croydon stargazing

Kenley Observatory, Kenley, 6, 13, 20, 27 April, 7.30pm

Every Saturday this month, Croydon Astronomical Society opens its observatory to the public for an evening of observing. It's weather dependent, so contact the society before making the journey.
www.croydonastro.org.uk

HOYS-CAPS citizen science

Birnie Village Hall, Moray, 5 April, 7.30pm

Dr Alexander Scholz gives an overview of star and planet formation and reveals the goals of HOYS-CAPS, a citizen science project to monitor young star clusters.
www.sigma-astro.co.uk

Kendal Moon-watching

Brewery Arts Centre, Kendal, 13 April, 8pm

Join Eddington Astronomical Society for a spot of lunar observing this month. For further information, see their website.
www.eas-online.org.uk

North Wales stargazing

Llandyrnog Village Hall, Denbighshire, 30 April, 7.15pm

Join Llandyrnog Astronomical Society for a talk on observatories of the world. Stargazing afterwards, weather permitting. Entry £2 including hot drinks and biscuits.
www.facebook.com/llandyrnogastro

CROYDON ASTRONOMICAL SOCIETY, EDINBURGH SCIENCE FESTIVAL X 4

PICK OF THE MONTH



▲ The 50th anniversary of the Moon landing inspires this year's 'frontiers' theme

Edinburgh Science Festival

Various venues, Edinburgh, 6–21 April

The annual science festival returns to the Scottish capital for two weeks of events on the theme of 'frontiers', with a focus on the 50th anniversary of the Apollo 11 Moon landing.

Science presenter Neil Monteiro hosts a pub quiz, board game and sci-fi evening asking teams to prepare for establishing new life on Mars.

In 'The Consolation of Physics', science writer Tim Radford guides guests through the vast unknown, from tiny particles to huge cosmic objects, while in 'The Magicians', author Marcus Chown profiles the scientists who predicted the existence of gravitational waves, antimatter and black holes.

Join Astronomer Royal Martin Rees for a look at the challenges facing humanity over the coming decades, or discover the sounds of distant worlds and undiscovered life forms with comedian Helen Keen, presenter of BBC Radio 4's *It Is Rocket Science.*

There is also a range of space – and other science-related events suitable for children and young people.
www.sciencefestival.co.uk

Space meets art

Rhondda Heritage Park, Pontypridd, 23 April, 10am

Cosmic craft for kids and families, including a planetarium show and a workshop turning images of planets, galaxies and nebulae into works of art. Tickets £7.50.
www.eventbrite.co.uk/e/space-meets-art-tickets-54674280244

Astronomy school

Crown East Scout Hut, Rushwick, Worcester, 18 April, 8.30pm

Worcester Astronomical Society hosts a series of short video presentations on cosmology and astronomy, followed by an observing session. Free to visitors. Arrive 8.30pm at the earliest.
www.worcesterastro.weebly.com

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FIELD OF VIEW

The dark thrill of an eclipse

How the heady mixture of wonderment and fear turned **Stuart Clark** into a totality chaser



Astronomy author **Dr Stuart Clark** is leading six tours to the spectacular Chile eclipse this summer with travel specialists Wendy Wu Tours. Visit **www.chileeclipse.co.uk** for more info

Nothing I had seen before prepared me for the experience of a total solar eclipse. The moment that I watched the Moon slide across the face of the Sun and I stood in the lunar shadow is something I will never forget – and will always want to experience again. The phrase 'once seen, never forgotten' doesn't convey the moment's emotional weight, but it could have been written with a total solar eclipse in mind.

Instantly, I understood why some people become 'umbraphiles' – people who chase eclipses across the world so that they can stand in the shadow of the Moon. I certainly wanted to see another one. Little did I know that when the time came, I would be advising almost 1,000 other people on how to see it.



RUI RICARDO/FOLIO ART

The first eclipse I witnessed was in Cornwall in 1999. It was raining. I still loved the experience, but when I saw a clear eclipse in Turkey in 2006, my life changed. The utter blackness of the Moon's silhouette, the little beads of light that ringed the Moon as the sunlight poked through the lunar valleys, the ghostly tendrils of the solar atmosphere that could suddenly be seen reaching into space. It was breathtaking. So when I was invited to be the astronomer on an eclipse trip to China in 2009, I jumped at the chance.

But as I stood waiting with so many people on that August day, I felt a great weight of responsibility resting on my shoulders. I had told everyone who would listen on that trip of the wonders to come. But when the day came, the clouds were threatening and I knew the spectacle stood a good chance of being hidden from our view. I felt I was letting everyone down. Thankfully, in the event, we caught glimpses through the clouds and it was a satisfying experience.

It was the feeling that I experienced in the moments of totality during the Turkish eclipse that I have continued to think about. Firstly, I was excited to be seeing the event. Then, I was stunned at the unearthly beauty of it. But as totality arrived, I was shocked at the shiver of fear that slid through me as the world around me plunged into an unnatural, unstoppable darkness.

I have since learned that philosophers would call this feeling the sublime. Scholars of aesthetics draw a distinction between the merely beautiful and the sublime. The beautiful is something that brings pleasure to the viewer. It is usually small(ish) and capable of being seen as a part of a larger whole. Above all, it is non-threatening; a flower or a human face can be beautiful.

The sublime is also beautiful, but is so large and it represents something so powerful that even though we are drawn to it, we are also overwhelmed by it. It is this cocktail of delight and fear that gives us the sublime feeling of awe. And in that sense, a total solar eclipse is the most awesome thing I have ever seen.

BBC

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BBC Sky at Night MAGAZINE

With the right preparation, pointing your scope out of an open window can produce better results than you might have thought possible

PETE LAWRENCE

Astronomy UNDER COVER

Can you observe the night sky without leaving your house? **Steve Richards** looks at your options when going outside is off the agenda

As the celestial bodies are most certainly 'outside', astronomy indoors may seem like a contradiction in terms, but there are many reasons why you might decide to do some astronomy from inside your home.

It could be that you live in a city and the ravages of light pollution render observations pointless. Poor weather, especially the cloudy UK skies, can drive you inside on many nights you'd set aside for stargazing. Equipment faults and incapacity due to illness can keep you from enjoying an observing or imaging session outside too.

For some, it's the technical challenge of operating astronomical equipment remotely from home that's appealing. Some fields of astronomy don't even require you to be outside at all. Many astronomers gain great pleasure from simply researching the subject or taking part in people-powered research and classification projects without ever touching a telescope. Others just want to dip their toe in the water before investing in high-cost equipment, not to mention a large chunk of their time.

Whatever your reason, there are many ways that you can get involved with astronomy without ever having to step outside. ▸

Observing from inside with a conventional telescope and eyepieces

PETE LAWRENCE X 3, MARK PAYNE GILL, WWW.ICASTRRONOMY.COM

Sitting outside on a cold night observing the sky above isn't for everyone. It takes some fortitude to assemble and align your equipment in the dark and cold before you even start your observing session. Then at the end you have to take it back down again. This is without doubt the best way to physically observe the night sky, but you can still stargaze from a more comfortable vantage point inside your home, if you are prepared to accept some compromises.

Observing through a closed window is a fairly futile exercise, as the distortions imparted by light refracted through the glass panels will destroy the fidelity of the views. Add in reflections and the light-sapping effects of grime build-up and you are really limiting the usefulness of your telescope. Opening a window and observing through the aperture removes the optical issues of the glass, but you will still be very restricted in the field of view you are able to observe. A better but still compromised solution is to open patio doors, if you have them, and site the mount straddling the threshold so that most of the telescope is outside. This means you can still observe from the relative comfort of inside your home.



Positioning your scope to straddle a patio door frame will give a better field of view than indoors

Don't underestimate the effect of poor temperature stabilisation between the inside and outside. Currents within the telescope will spoil the view and the motion of air moving from the warm room into the cold outside will combine to create an unstable view too.

If you have a southerly view, you may want to consider solar astronomy. The temperature differential isn't so great during the day, meaning you should have more stable views.



Solar observing is achievable from the comfort of your home

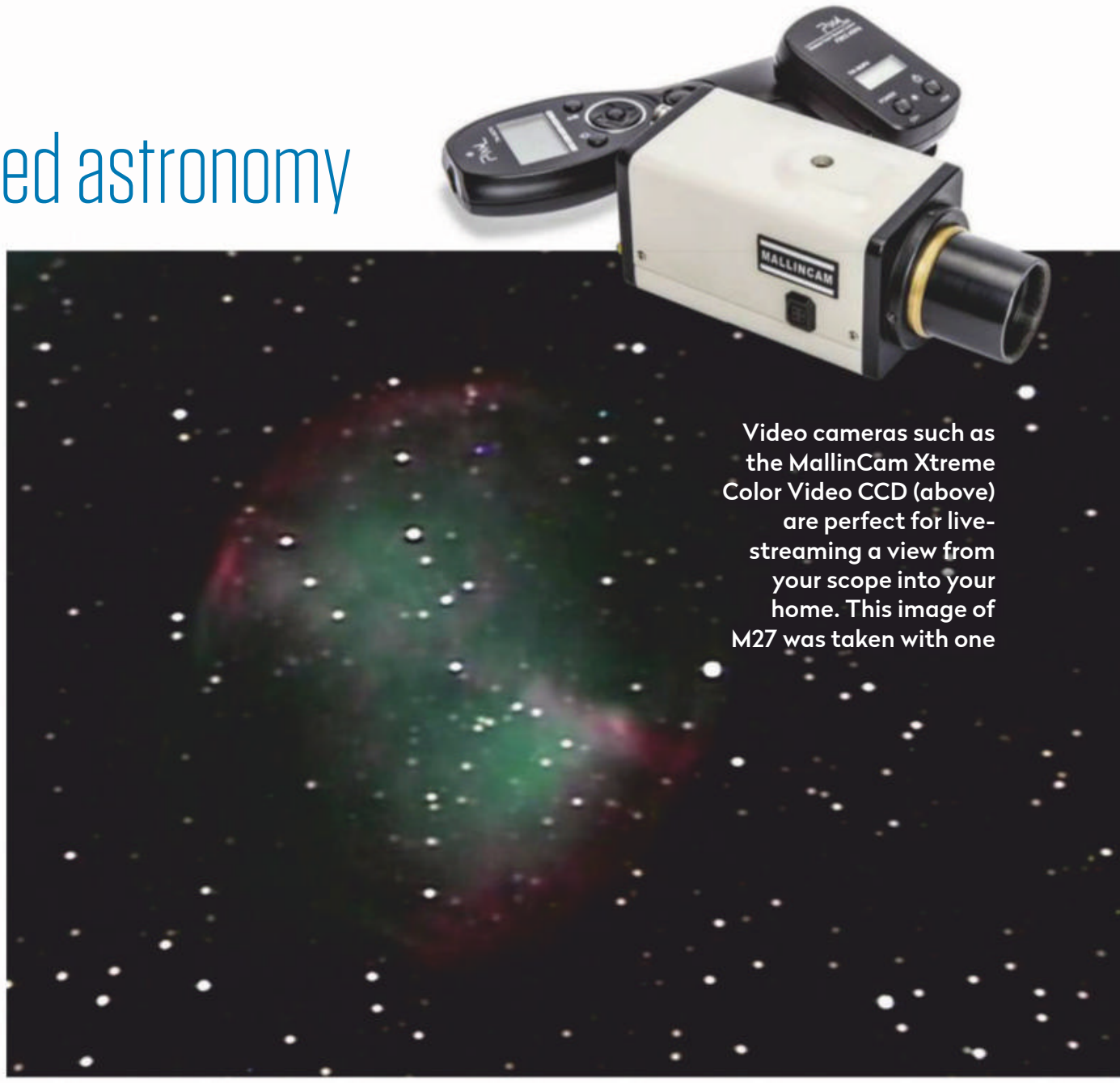


Observing through a closed window is not recommended, due to reflections and distortions

Electronically assisted astronomy

While Solar System objects are eye-catching even through modest equipment, the cause of most disappointment in newcomers to astronomy is how relatively dim and colourless deep-sky objects are. There is only so much light that you can project into your eye and because of the way your eyes function in the dark, colour is especially difficult, if not impossible, to see.

Electronically assisted astronomy comes to the rescue in the form of video or high-frame-rate cameras with very sensitive colour sensors that continuously stack image data during a session. They produce bright and colourful images in a short period of time – a process known as integration. This means that your exposure to the outside is limited to just setting up the equipment at the start of the session, running a cable into the house to carry the video data and dismantling it at the end of the session. The rest can be carried out inside as you watch the images develop on your monitor as if by magic.



Video cameras such as the MallinCam Xtreme Color Video CCD (above) are perfect for live-streaming a view from your scope into your home. This image of M27 was taken with one

Imaging remotely with your own or time-shared equipment

Dark skies are at a premium these days. It's not always convenient to haul all your equipment to a dark site, so a relatively new industry has sprung up offering either use of shared equipment or hosting of your own kit at a location with low levels of light pollution and good weather.

Although this is not a low-cost solution, the considerable advantage of a high number of imaging nights in great conditions is very appealing indeed.

To offset the cost, it's common for astronomers to join a syndicate to buy and run the equipment, either pooling all the images captured or creating a schedule for each syndicate member to use the system individually. Telescopes are normally housed in long, low buildings with state-of-the-art computer control, communication and weather monitoring facilities, with roll-off roofs giving extensive views of the night sky above about 30° altitude. Access is via high-speed internet connection using remote access software like AnyDesk or TeamViewer to give you full control of the equipment from the comfort of your home using a laptop or desktop PC. There are several companies specialising in remote hosting, including IC Astronomy, e-EyE, Deep Sky West (DSW) and itelescope.net.

Of course, you don't have to have your equipment hosted by an organisation abroad. You can just as readily set up a remotely controlled observatory in your own back garden, although you would still end up finding yourself at the mercy of the fickle UK weather. ▸



▲ **IC Astronomy provides expert equipment which can be remotely accessed by a home PC**

Radio and meteor astronomy

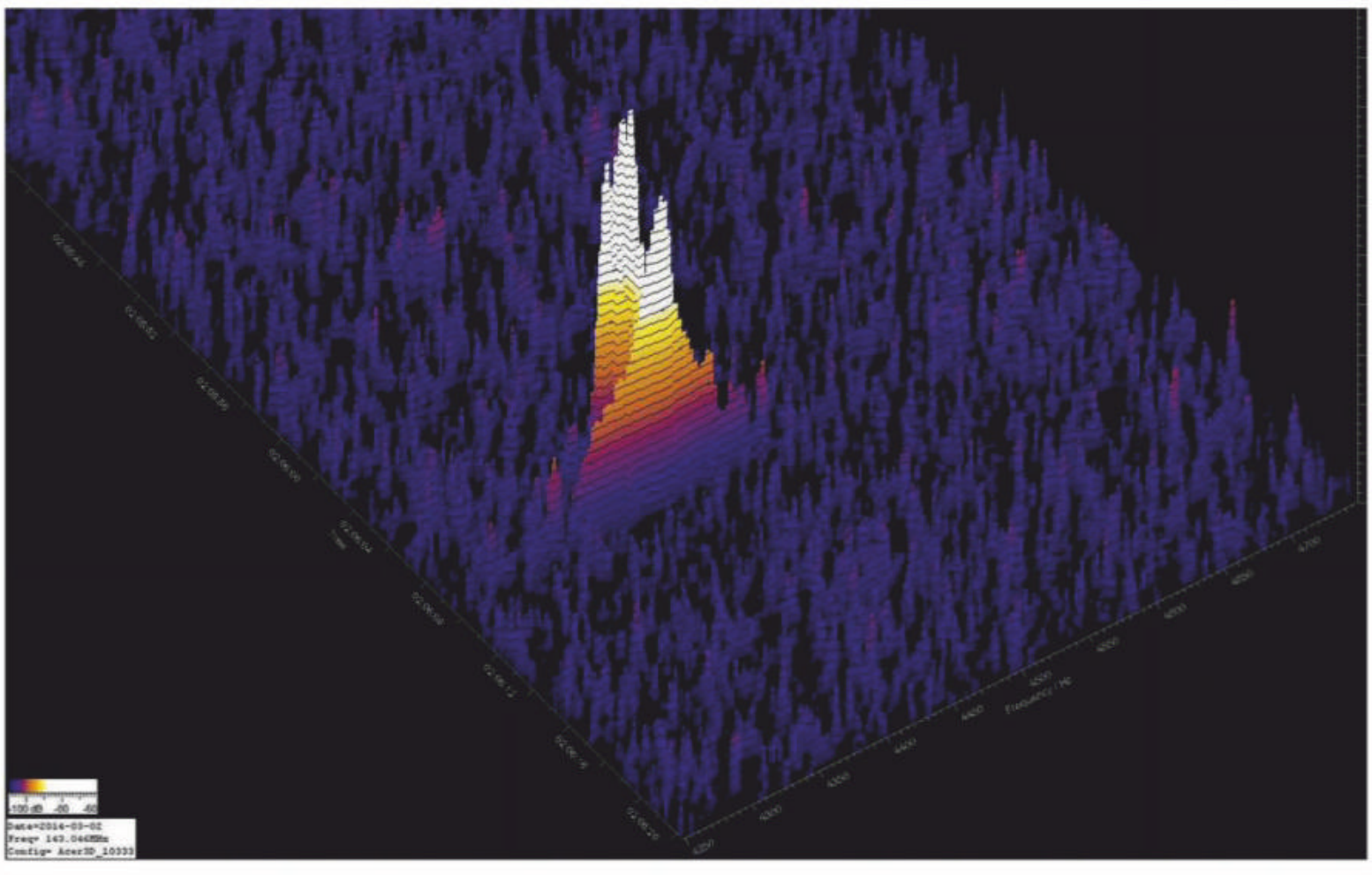
Not all fields of astronomy require you to be outside. Both radio and meteor detection astronomy can be interesting activities you can operate from indoors.

Although radio astronomy is a very advanced form of astronomy, requiring specialised receiving and monitoring equipment as well as antennae in your garden, its technical and intellectual challenges can be very rewarding. Studies of the Sun, Jupiter, Milky Way, radio galaxies and supernova remnants are all topics within reach of the amateur astronomer, although some will require a large external area for the antennae. Visit **www.britastro.org/radio/beginning.html** for more information on this unique aspect of astronomy.

Meteor detection, on the other hand, is both fascinating and relatively easy to take part in as the equipment requirements are very modest. Typically, you will need a suitable receiver, comprising of a Software-defined Radio (SDR) dongle that simply plugs into one of your PC's USB ports and an easy-to-make yagi antenna designed to work optimally at 143.050MHz plus. Free software is available to operate the receiver and log the presence of meteors over time in an attractive graphical display. Visit **www.popastro.com/main_spa1/meteor/radio-meteor-observing** for more information.



▲ A home-made aerial can be used to pick up the radio signals reflected by meteor trails during the daytime



PAUL HYDE X 2, WWW.ZOONIVERSE.ORG X 3, HTTPS://SKYVIEW.GSFC.NASA.GOV

◄ Software, such as Spectrum Lab, can show meteor-reflected radio signals in three dimensions



Steve Richards is an astro imager and author of *Making Every Photon Count: A Beginner's Guide to Deep Sky Astrophotography*

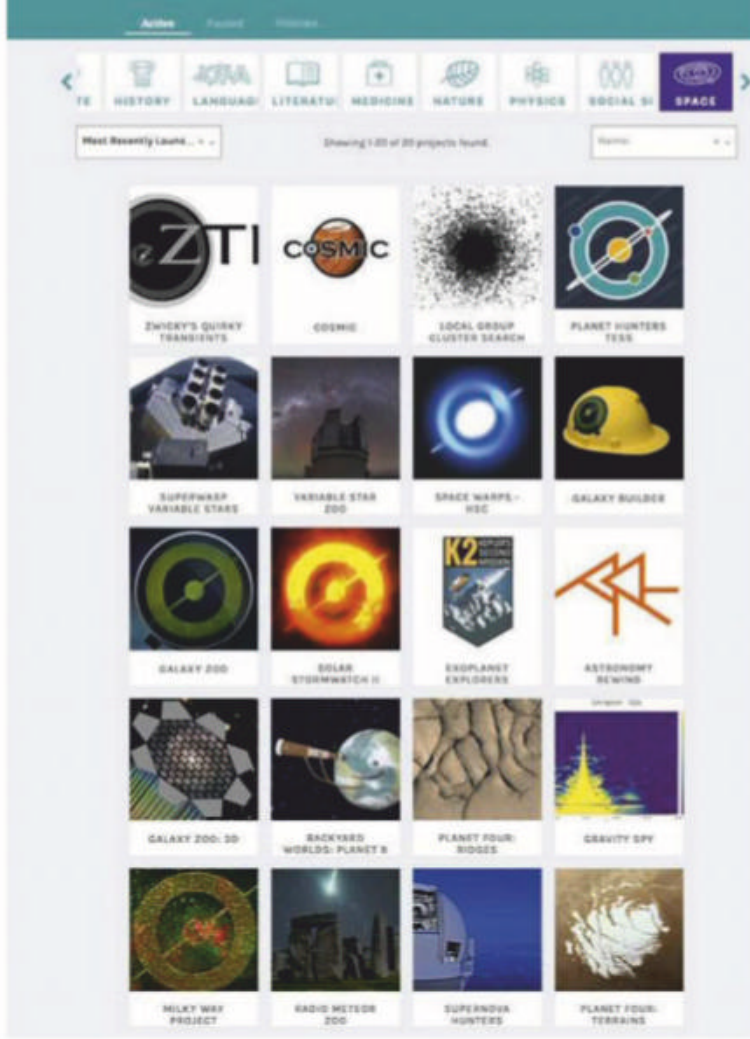
Zooinverse – online astronomy research

Some astronomy-related pursuits don't require any equipment at all, just access to a computer and the internet, yet they allow you to take part in real science projects.

Sophisticated though modern computers and software may be, they are still no match for the cognitive power of the human eye and brain. When professionals need large data sets analysed, classified and logged, they turn to citizen scientists – members of the general public that sift through the information from the comfort of their own homes.

There's a wide range of subjects to explore, ranging from the classifying of surface features on Mars, to hunting for star clusters in our local group of galaxies, or identifying variable stars near the centre of the Milky Way. There's a chance to search for distant galaxy clusters and identify new exoplanets using data from the Transiting Exoplanet Survey Satellite (TESS). It's also possible to classify galaxies by their shapes, track solar storms to help improve space weather forecasting and discover supernovae using data from the Hawaii-based Pan-STARRS1 telescope. There are many other areas of interest to explore.

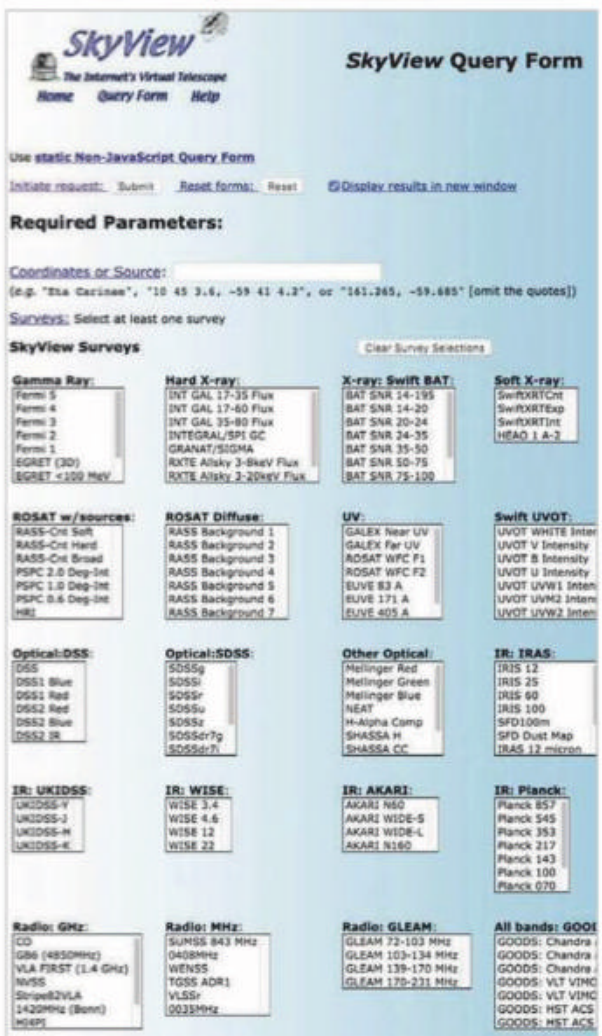
You can invest as much time as you want – be it the occasional dip in or spending hours discussing findings on the forums. Some volunteers end up being listed as contributors on scientific papers, so you could find yourself being recognised for your contributions, especially if you discover something on the unusual side. Visit **www.zooniverse.org** to learn more about how you can become involved in astronomy projects.



▲ **Zooniverse's (top) compelling online projects include Galaxy Zoo and Planet Hunters TESS**

Processing images available in the public domain

Astrophotographers often complain that during the long gaps between good imaging conditions, their processing skills begin to fade. One way to keep your talents honed is by processing some deep-sky image data from NASA's SkyView portal.



You can access the raw FITS files by filling in a query form and downloading the data from the Digital Sky Survey 2 database at **https://skyview.gsfc.nasa.gov**.

Red and blue FITS digital image files from the DSS2 surveys can be obtained in various resolutions, centred on the sky at the coordinates – right ascension (RA) and declination (dec.) – that you enter in the query form. You can then synthesize (create) a green channel to make an RGB (red, green, blue) colour image to process in your normal image-processing workflow. This will not only keep your hand in with processing, but will give access to stunning images captured by professional observatories. The extensive sky coverage that's available means you can construct huge mosaics.

This is an excellent tool for research purposes too, because in addition to the light spectrum data there is also a wealth of gamma ray, R-ray, UV, IR and radio channels to be explored. You may never need to go outside again.



▲ **NASA's SkyView portal gives astrophotographers a chance to hone their processing skills**

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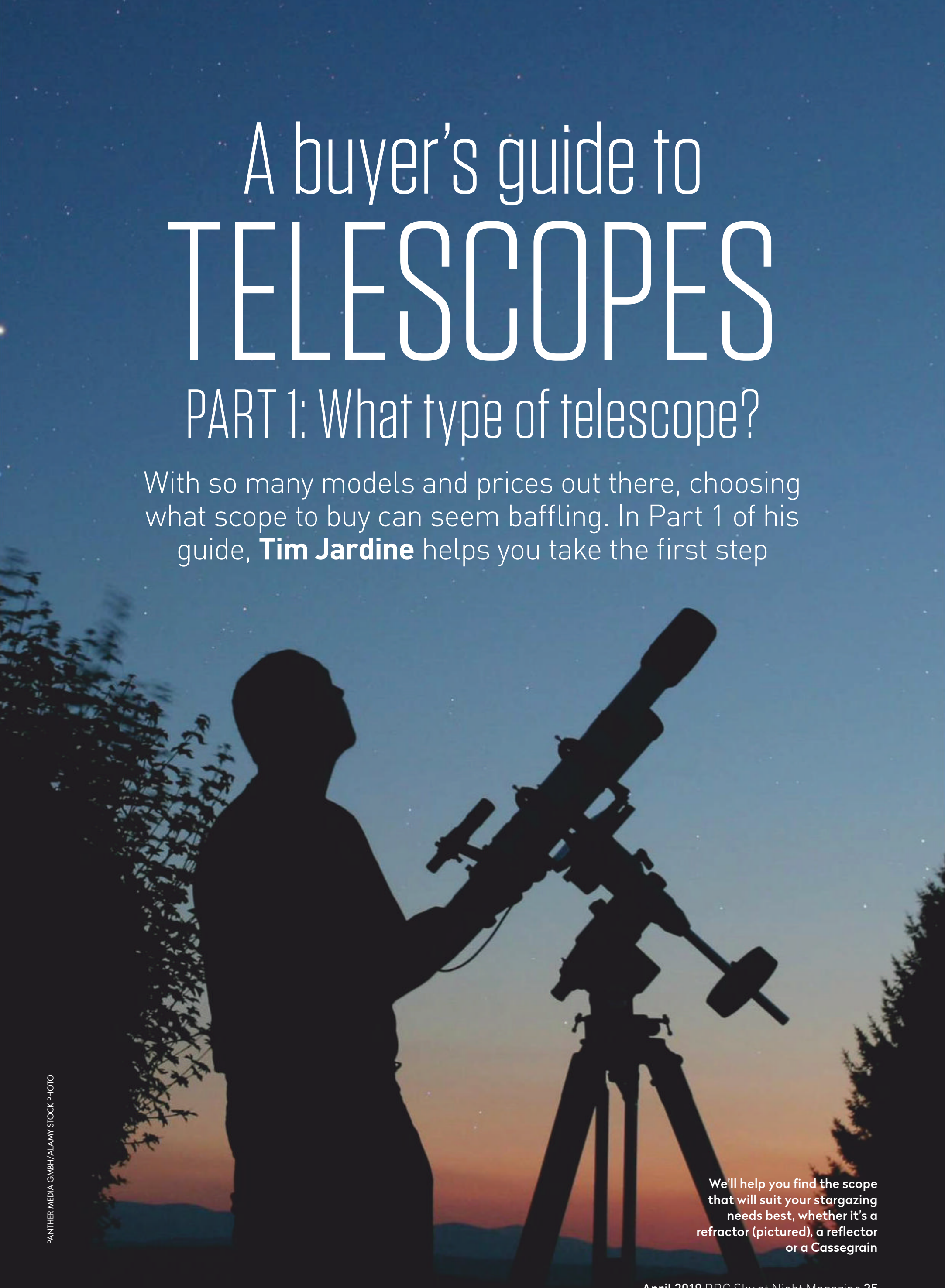
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A buyer's guide to TELESCOPES

PART 1: What type of telescope?

With so many models and prices out there, choosing what scope to buy can seem baffling. In Part 1 of his guide, **Tim Jardine** helps you take the first step



PANTHER MEDIA GMBH/ALAMY STOCK PHOTO

We'll help you find the scope that will suit your stargazing needs best, whether it's a refractor (pictured), a reflector or a Cassegrain



► **A small refractor is ideal for beginners and is well-suited for wide views of the night sky**

Tucked away in the corners of many garages and spare rooms sit dormant telescopes. Telescopes designed to gather views of moons, stars and planets, no doubt purchased with excitement, but now sitting forlornly gathering dust. Perhaps some of these scopes were too cumbersome to take in and out at night, others too complicated to set up, or maybe underwhelming views led to disappointment.

With this in mind, as we look at the question 'What type of telescope should I buy?', we can say from the outset that the best telescope for anybody will be one that is practical and comfortable to use regularly, and that provides exciting views of the night sky.

Admittedly, there is a bewildering array of equipment available. However, we can divide all those variations into just three basic types: refractors, reflectors (including Dobsonians) and Cassegrains. Most people will recognise the first type. Refractors have glass lenses at the end of a tube to bring a magnified view of the sky to focus. The second type, invented by Isaac Newton, are known as reflectors because they use mirrors instead of lenses to achieve the enlarged sky view. Finally, Cassegrains involve mirrors with a hole in the middle. Let's have a look at the benefits and compromises of each.

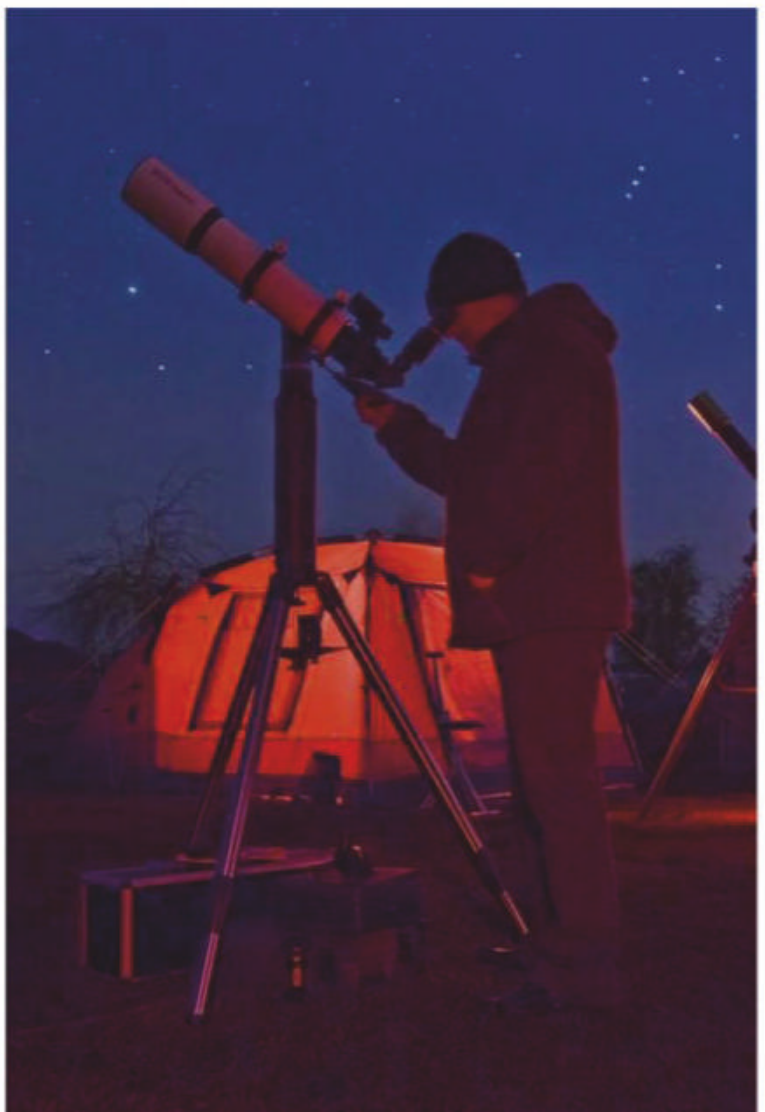
"The best telescope for anybody is one that is practical and comfortable to use regularly, and that provides exciting views of the night sky"

Refractors

As the most popular type of telescope, refractors have many appealing qualities. They tend to be lightweight, easy to set up and intuitive to use, give sharp views and require practically no maintenance. Interchangeable eyepieces offer varying magnifications and increase the range of viewable objects. Good portability allows for trips to enjoy darker skies away from light-polluted areas. However, there is a saying in the world of telescopes that 'aperture is king'. Or, in basic terms, the wider the front end of the scope the better. With their ability to gather more starlight, bigger telescopes yield more impressive views.

In this respect refractors have limits. Very large lenses are prohibitively expensive and quite unmanageable for amateurs. Refracting telescopes available today therefore tend to have front lenses between 60mm and 150mm in diameter. Within that range we find inexpensive models with a single front lens, up to telescopes with multiple lenses that provide a sharper, more natural view, at a premium price point. The quality of the optics in the telescope, determined predominantly by their cost, will have a significant bearing on the quality of the views, and the really cheap refractors that tend to be popular at electrical goods and camera shops are often disappointing. Generally speaking, smaller refractors less than 90mm diameter are best suited for wider views of the night sky, which might include star clusters like the famous Pleiades, M45. Although some detail may be seen when observing Jupiter and Saturn as well as their moons, both planets will appear quite small and very bright in the view. Some brighter galaxies and nebulae may be visible under good skies, and with experience it becomes easier to pick out the interesting objects. However, larger refractors 100mm in diameter and

► **A properly mounted refractor can provide many hours of stargazing delights**



WWW.SECRETSTUIDO.NET X 3, JON HICKS, PAUL WHITFIELD



► A Dobsonian, where a reflector is mounted on a rotating base, offers some of the most rewarding views of the night sky



◄ The handy, compact size of a tabletop Dobsonian makes it an ideal scope for children

upwards can really open up the skies, and under reasonably dark skies there will be hundreds of deep-sky objects that can be viewed, including galaxies, globular clusters of stars and bright nebulae. Surface colours and details may be seen on Saturn, Jupiter and even Mars on a good night. Lunar views too should be sharp, with good definition in craters and rille features (valleys and trenches), as the larger optics enable the telescope to reveal more detail. There is no doubt that a decent refractor, on a sturdy mount or tripod, can provide a thrilling stargazing experience, and whet the appetite for further sessions for many years.



Reflectors

Reflecting telescopes are quite different in nature, having an open tube at the front and a round mirror inside the bottom of the tube, called the primary mirror. Light entering the tube is reflected back inside the tube onto a much smaller angled secondary mirror, and then out through the side of the telescope near the top end, which is where the interchangeable eyepieces go. This design allows for much larger apertures than are possible with refractors, and amateur reflectors are available right up to a whopping 500mm diameter.

There are two ways of using reflectors. Smaller models up to 300mm or so can be used on tripod-style mounts similar to those used for refractors. A popular alternative option, though, is to mount the telescope tube onto a rotating base that sits on the floor. This can be turned freely around, while the telescope can pivot up and down and thus be pointed anywhere in the sky. Telescopes mounted in this way are known as Dobsonians and, penny for penny, offer the most cost-effective and rewarding views of the deep sky.

Smaller reflectors up to 150mm in diameter also come on mini mounts that sit on a table top. Easy to use, compact and quick to set up, these tabletop Dobsonians are ideally suited for introducing children to using a telescope.

The views offered by a relatively modest reflector can compare favourably with those offered by expensive refractors. Dobsonians may be elegantly simple affairs – no wires, no batteries, you just point it at what you want to see – or they may include a full 'Go-To' control, which automatically points the telescope at hundreds of sky objects.

There are compromises, as reflectors need their mirrors adjusting from time to time (although this shouldn't put you off), and bigger models can be heavy and bulky. The largest Dobsonians may even ►

▼ A starter reflector will only require a simple mount





▸ need a stepladder to get to the eyepiece at times.

Cassegrains

In use, Cassegrain telescopes are quite similar to refractors, in that you point the front end at the sky and you look into an interchangeable eyepiece on the back. Comparatively heavy, they tend to have shorter tubes, and this compactness makes them ideal where storage space is limited. These telescopes may need a little tweaking from time to time to make sure the mirrors are lined up properly. Cassegrain designs give a comparatively more magnified view for a given size of eyepiece, and if you want to experience the best views of the planets and our Moon, a Maksutov-Cassegrain or a Schmidt-Cassegrain telescope may well be the best option. When sky conditions allow, details can be

▲ **From Saturn's rings to Jupiter's colour bands, Cassegrains are great for picking out planetary details**

"Cassegrains tend to have shorter tubes, and this compactness makes them ideal where storage space is limited"

seen within the coloured bands of Jupiter and different colour bands on Saturn, along with the Cassini division and other details in Saturn's glorious ring system, not to mention polar caps and features on Mars. Of course, other deep-sky objects may be viewed, with larger aperture Schmidt-Cassegrains over 150mm in diameter providing the most satisfying experience. Although the views may not be quite as 'pin-sharp' (where the main subject is clearly in crisp focus) as those from refractors, they are a popular choice as a happy compromise between large enough aperture and manageable size. Because of the higher magnification views these telescopes will give you, the object being observed will move out of view in the eyepiece more quickly, and so they are often purchased with electronic Go-To tracking mounts to follow the targets as they move.



◂ **A compromise between a refractor and a reflector, a Cassegrain combines higher magnification with compact design**

Taking the next step

Now we've looked at the main telescope types, you can decide which one is right for you by thinking about where and how you will use it – maybe at home, or perhaps at dark-sky sites. All three designs are available as basic models or with fully computerised Go-To controls and even built-in wi-fi for operation via smartphone. A 'grab and go' simple setup may best suit your needs, or you may want more complicated equipment with fully automatic operation to reveal more wonders of the night sky. Whatever your choice – refractor, reflector, Cassegrain – it is advisable to make your purchase from specialist astronomy dealers that know all about the telescopes they offer and can answer your questions.



Tim Jardine is an experienced amateur astronomer and astrophotographer

Next month

Part 2: accessories to go with your new scope

WWW.SECRETSTUDIO.NET X 5, PAUL WHITFIELD X 4

Selecting your scope

There's a wide variety of scopes available on the market. Here's our pick of some top performing models

Refractors



Sky-Watcher Evostar-90 AZ Pronto

£259 • www.opticalvision.co.uk

An easy to set up and use entry-level refractor with useful accessories – including two eyepieces and a finderscope – mounted on a lightweight, well-constructed tripod.

Explore Scientific AR152 refractor

£713 • www.rothervalleyoptics.co.uk

A large aperture refractor with achromatic optics providing bright views. Supplied with a carrying handle and finderscope, it requires a sturdy mount.

Reflectors



Sky-Watcher Explorer 130PS & Avant mount

£219 • www.opticalvision.co.uk

A firm favourite with beginners, this reflector is supplied with two eyepieces, a red-dot target finder and dual mode mount, giving enjoyable views.

Orion Optics VX8 f/4.5 Newtonian reflector

£528 • www.orionoptics.co.uk

The 200mm mirror inside this reflector helps to reveal the sky's hidden gems. Coupled with a suitable mount, this telescope enables serious observation of the night sky.

Dobsonians



Meade LightBridge Mini 130mm

£229 • www.widescreen-centre.co.uk

Tabletop Dobsonians are compact, portable and easy to set up, making them suitable for impromptu observing sessions or transporting to a dark-sky site.



Sky-Watcher Skyliner 200P

£275 • www.firstlightoptics.com

Deservedly the UK's most popular Dobsonian, this easy-to-use 8-inch telescope provides stunning views at a remarkable price. Perhaps the ideal first telescope?

Cassegrains



Sky-Watcher Skymax 127T

£254 • www.opticalvision.co.uk

Compact and portable and good for lunar and planetary observation, along with brighter deep-sky objects. Supplied with 10 & 25mm eyepieces and red-dot finder.

Celestron NexStar 8SE

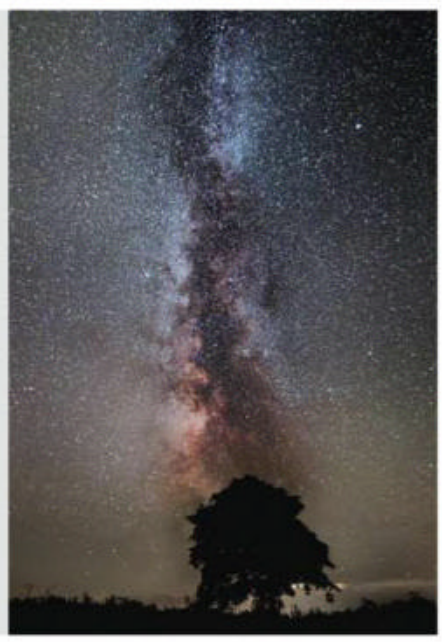
£1,299 • celestron.uk.com

Serious observation is possible with this sturdy, fully computerised Go-To scope. It provides excellent views of deep-sky objects and after completing sky alignment, locates them for you.

DARK SKY RETREATS

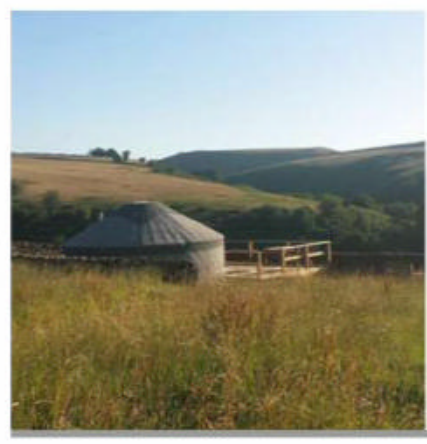
Here's a great selection of places to stay where you can relax in comfort and enjoy the experience of a dark sky above

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Holiday in our lodges near the North Devon Coast and image the night sky with our dome based, fully equipped 25cm Skywatcher Quattro on an EQ6 mount. We also offer AstroScape photography and education courses on Astromony, plus visual observing with our half metre Dobsonian!

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West Burton in its rural setting is estimated to have light pollution levels for stargazing, or drive up on to the nearby moorland itself, plus local dark sky sites at Buckden and Bolton Castle. Delightful, well-equipped, refurbished 4★gold award accommodation with walks in all directions. **Sleeps 4**, wood burner, garden, **welcomes dogs**.



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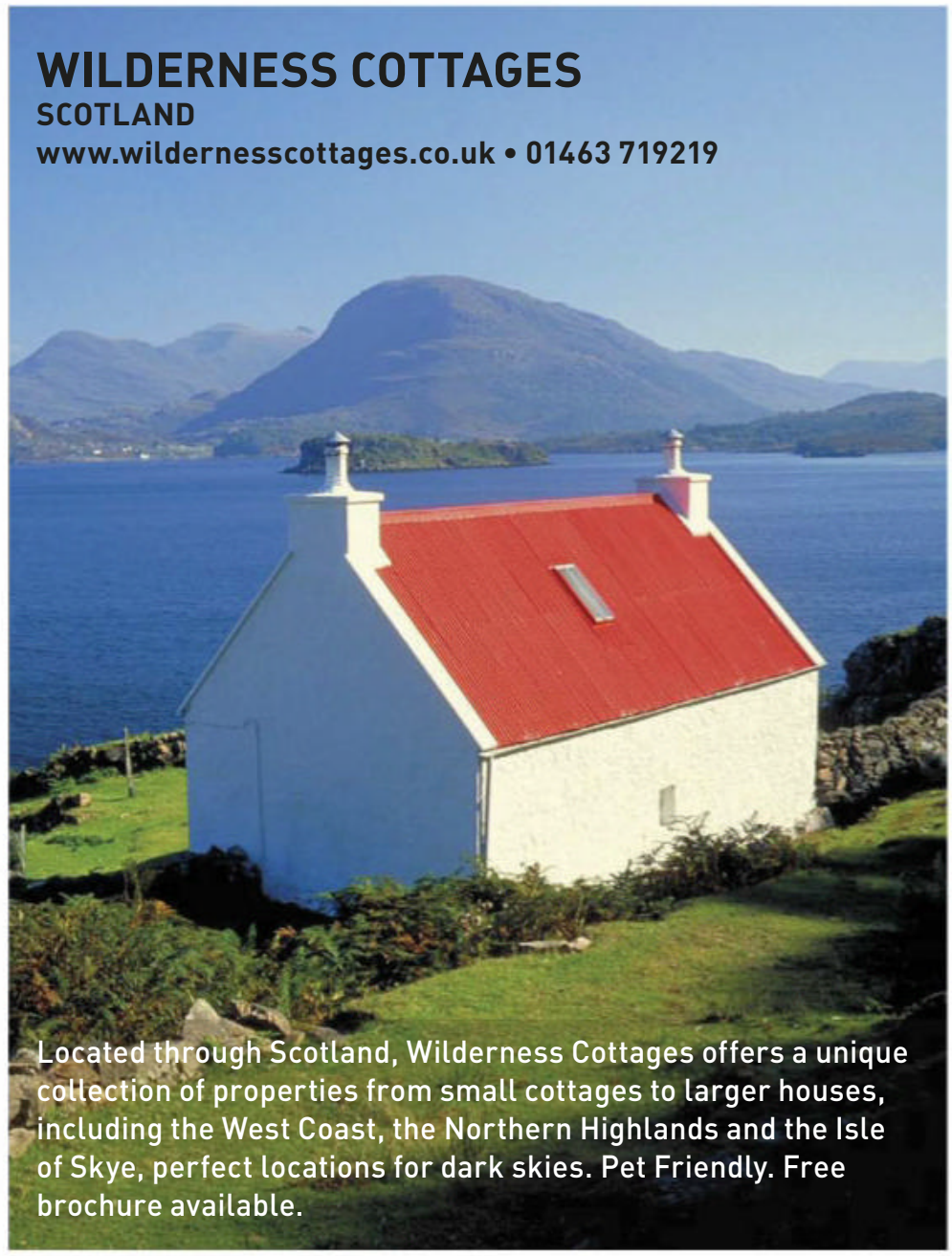
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BBC Sky at Night MAGAZINE

16-PAGE CENTRE PULLOUT

The Sky Guide

APRIL 2019

MARS AND THE PLEIADES

The open cluster gets a visit from the Red Planet

HUNT A QUASAR

Can you find these distant targets?

24 COMAE BERENICES

Spring's hidden treasure

PETE LAWRENCE

About the writers



Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four



Stephen Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Red light friendly



To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Don't miss...

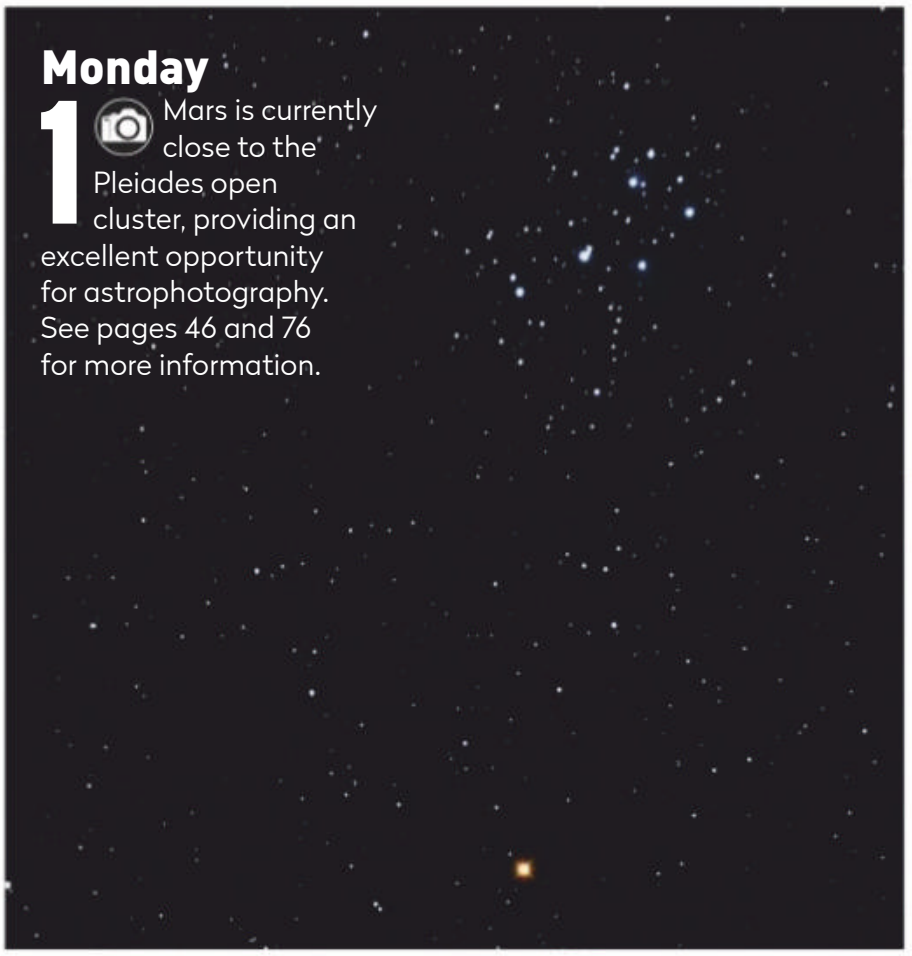
- A striking lunar sea
- Some great shadow transits of Jupiter
- Pallas at opposition in Boötes
- Last chance to spot the spring zodiacal light

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky, sign up to our newsletter: **www.skyatnightmagazine.com/iframe/newsletter-signup**

APRIL HIGHLIGHTS

Your guide to the night sky this month



Monday 1

Mars is currently close to the Pleiades open cluster, providing an excellent opportunity for astrophotography. See pages 46 and 76 for more information.

Tuesday 2

Mag. +0.9 Mercury, a 9%-lit waning crescent Moon and mag. –3.9 Venus appear close in the morning sky. This is a tricky event to see due to its low altitude just before sunrise.

Wednesday 3

With little interference from the Moon, this is an ideal time to look for the zodiacal light, a rounded conical glow aligned along the ecliptic. With dark skies, it will typically be in the west for 90 minutes, starting 90 minutes after sunset.

Friday ▶ 5

Minor planet 7 Iris is at opposition today. It appears as a mag. +9.4 object in Corvus, not too far from M014, the Sombrero Galaxy. See page 53.



Tuesday ▶ 9

This evening the thickening lunar crescent, now 20%-lit, will sit just to the east of the bright orange star Aldebaran (Alpha (α) Tauri).



Wednesday 10

The 29%-lit waxing crescent Moon gives a chance to see Alexander's Beaded Rim, a clair obscur effect. View around 23:30 BST (22:30 UT) to see star-like points at the rim of crater Alexander. 2 Pallas reaches opposition at mag. +7.9 in Boötes. See page 47.

Thursday 11

Mercury reaches greatest western elongation at 27.7°W. Despite this, it is poorly positioned in the morning sky, rising only a short time before the Sun.

Tuesday 16

Mag. +0.3 Mercury and mag. –3.8 Venus are just 4.3° apart in this morning's sky just 30 minutes before sunrise. This will be a difficult spot, requiring a very flat eastern horizon.

Monday 22

The Lyrid meteor shower peaks tonight, but the presence of a bright Moon will interfere with the visual show. The shower has a ZHR of 18 meteors per hour.

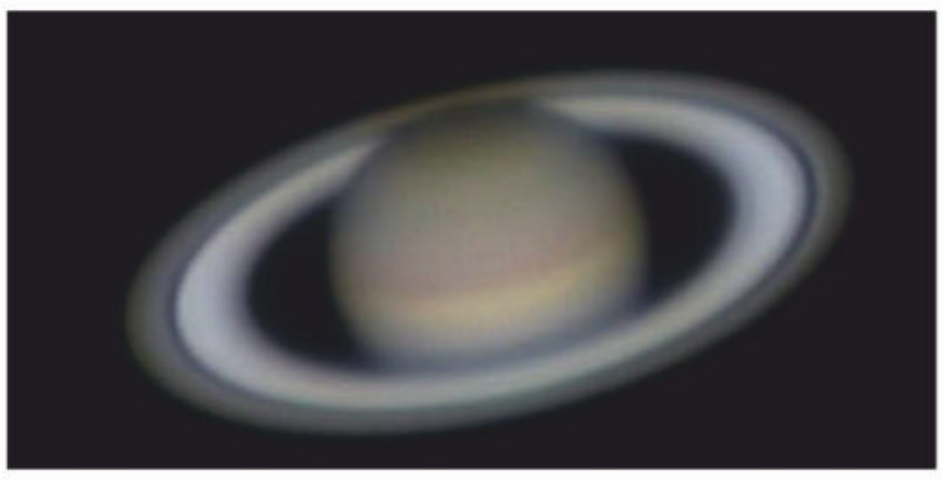
Tuesday ▶ 23

A telescopic view of Jupiter just after 01:00 BST (00:00 UT) will show Ganymede's shadow in transit. The mag. –2.3 planet appears close to an 84%-lit waning gibbous Moon. At 04:40 BST (03:40 UT), both appear due south, separated by 4.5°.



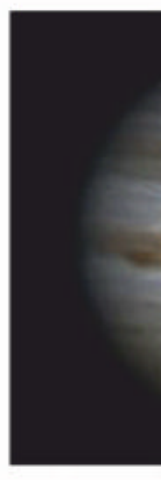
Thursday ▶ 25

This morning the 67%-lit waning gibbous Moon will appear 5.8° west of mag. +0.9 Saturn. Tomorrow morning the now 57%-lit waning gibbous Moon will be 6.7° to the east of the planet.



Tuesday ▶ 30

A telescopic view of Jupiter just after 04:40 BST (03:40 UT), as the sky is brightening, will reveal Ganymede's giant shadow beginning its transit across the Jovian disc. This should remain visible as the dawn breaks (see page 47).



PETE LAWRENCE X 8



Thursday ▶

4 There is a great opportunity to see Io's shadow appear on Jupiter's disc this morning. View from around 03:00 BST (02:00 UT). Io itself will be in transit from around 04:05 until 06:15 BST (03:05 until 05:15 UT).

Saturday

6 This evening sees the peak of the weak Kappa-Serpentids meteor shower. Although it has a low ZHR (zenithal hourly rate) of 4 meteors per hour, the sky will be dark thanks to a new Moon on 5 April.

Sunday

14 A telescopic view of this evening's 73%-lit waxing gibbous Moon will reveal the clair obscur effect known as the Jewelled Handle. This is formed by morning sunlight illuminating the tops of the Jura Mountains.

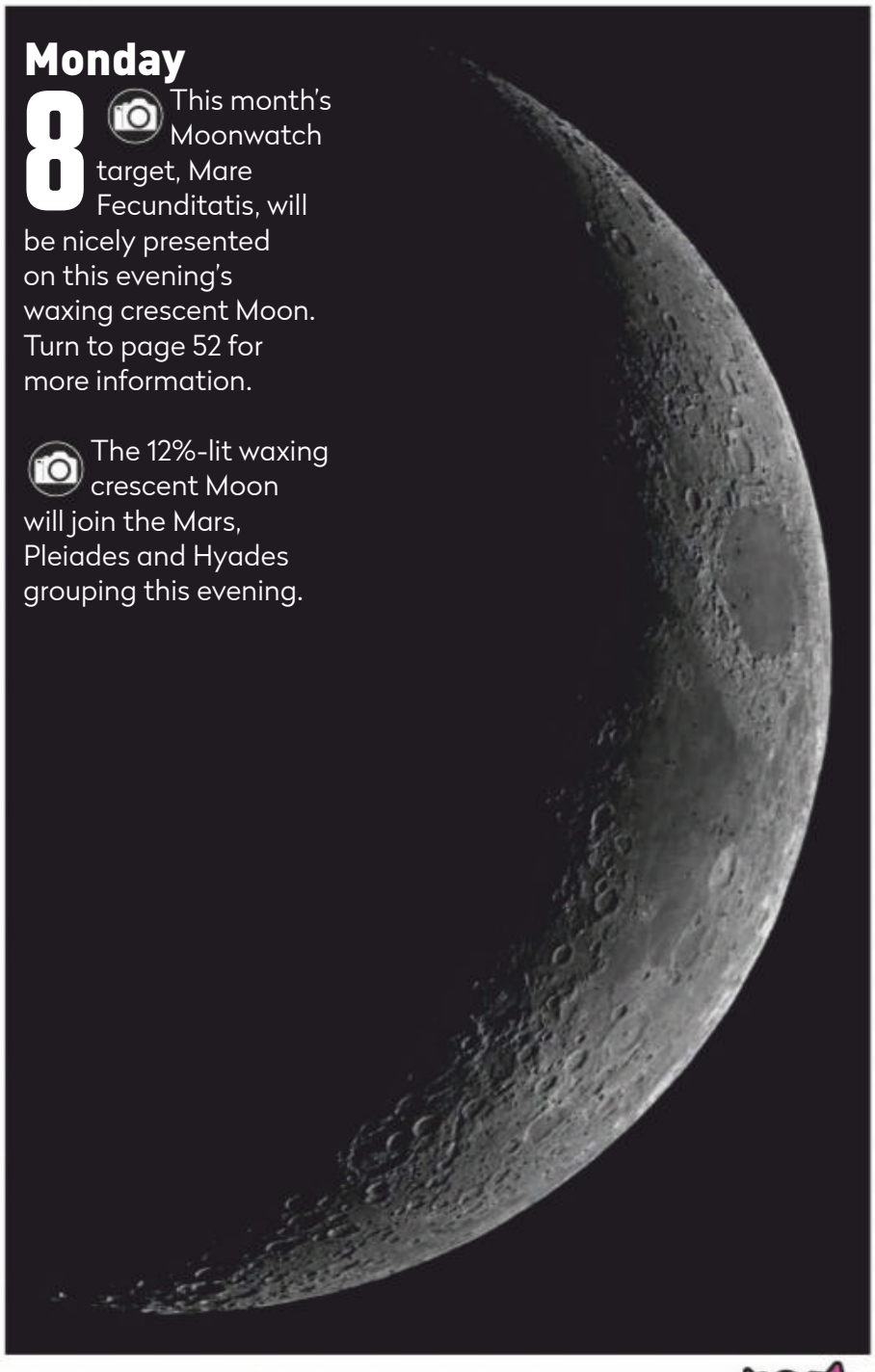
Wednesday

24 Minor planet 44 Nysa reaches opposition at mag. +9.9 in Virgo. This evening Nysa is located about 1° south of Iota (ι) Virginis.

Monday

8 This month's Moonwatch target, Mare Fecunditatis, will be nicely presented on this evening's waxing crescent Moon. Turn to page 52 for more information.

The 12%-lit waxing crescent Moon will join the Mars, Pleiades and Hyades grouping this evening.





Family stargazing – Mars and M45

The passage of Mars south of the Pleiades open cluster at the start of April is an ideal event for youngsters to observe. Both Mars and the Pleiades can be seen with the naked eye, so find them this way at first before making a challenge of trying to see them through binoculars. This can be tricky to get right if binoculars are unfamiliar, and it may take several attempts. The Pleiades are unmistakable through binoculars and make a great reward for all the effort of trying to get them in view.

www.bbc.co.uk/cbeebies/shows/stargazing

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'.

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

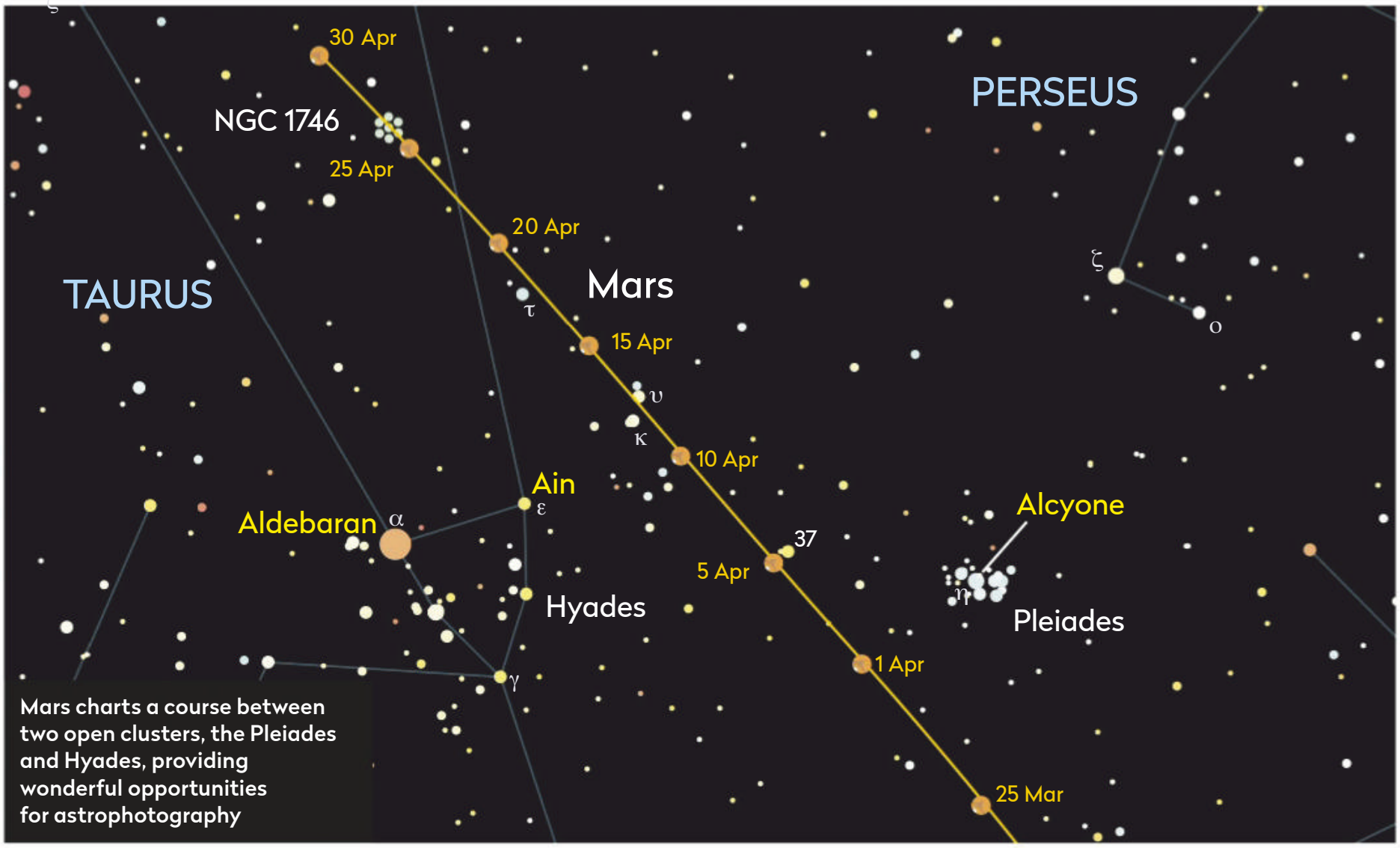


GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **http://bit.ly/10_Lessons** for our 10-step guide to getting started and **http://bit.ly/First_Tel** for advice on choosing a scope.

THE BIG THREE

The three top sights to observe or image this month



Mars charts a course between two open clusters, the Pleiades and Hyades, providing wonderful opportunities for astrophotography

DON'T MISS

Mars and the PLEIADES

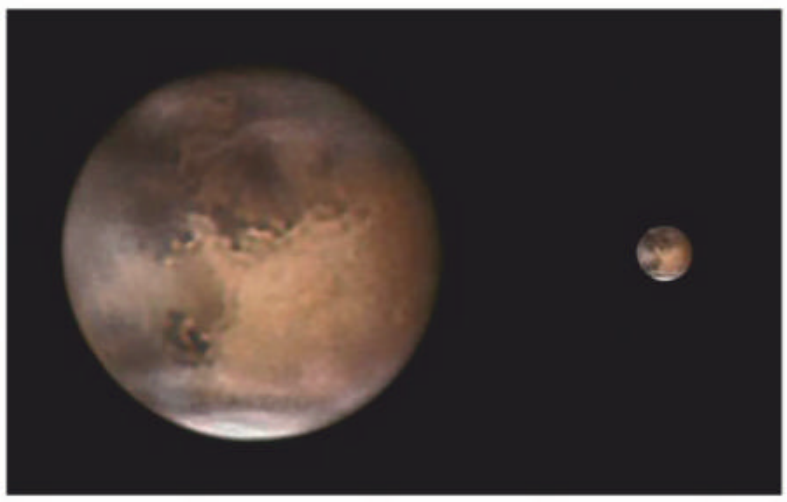
BEST TIME TO SEE: 1–10 April

Mars is a frustrating planet to observe. Coming to opposition every 2.1 years, it is close enough to show a decent disc size for just a few months around this time. After this the distance between Earth and Mars increases and the planet appears to shrink through the eyepiece. This makes it harder to see surface detail.

Following opposition, Mars does a clever trick. It virtually stands still relative to the horizon at the same time of night. The last opposition occurred on 27 July 2018, when Mars had an apparent size of 24 arcseconds but from the UK it was low in altitude, even when at its highest point due south. Then, as it started to pull off its standing still trick, it gained altitude as it appeared to shrink.

At present, Mars looks tiny through the eyepiece, at around 4 arcseconds across. It's also a lot dimmer than it was at opposition, currently shining at mag. +1.5 compared to –2.8 at the end of last July. Its characteristic salmon-pink colour stands out well, though, and this makes it easy to identify.

This month Mars passes south of the beautiful Pleiades open cluster, M45, in Taurus, tracking between the Pleiades and Hyades clusters. This presents a great opportunity for astrophotography (see page 76).



▲ **Comparing the apparent size of Mars from last opposition (27 July 2018) to how it currently looks (right)**

At present, Mars is unable to achieve its highest point in the sky, due south, in darkness. By the time the sky darkens, around 22:00 BST (21:00 UT), the planet appears 22° up in the west.

On 1 April it lies 3.4° south-southeast of the Pleiades. Mars does not linger and moves rapidly through Taurus over the following evenings. On 5 April, look out for mag. +4.3, 37 Tauri, 0.3° to the north of the planet as darkness falls. Mars will appear midway between Alcyone (Eta (η) Tauri), the brightest star in the Pleiades, and Ain (Epsilon (ε) Tauri), the northernmost star in the main V-shape of the Hyades.

Mars drifts further from the Pleiades as it passes north of the Hyades. On the evenings of 8 and 9 April it is joined by the waxing crescent Moon, making another great opportunity for astrophotography.

On 12 April, Mars forms a tight triangle with mag. +4.3 Upsilon (υ) and +4.2 Kappa (κ) Tauri. Both stars are separated by just over half a degree in the sky. On the evening of 18 April it passes 20 arcminutes north of mag. +4.3 Tau (τ) Tauri. On 25 and 26 April, Mars will pass in front of the sixth magnitude open cluster NGC 1746.

Pallas at opposition

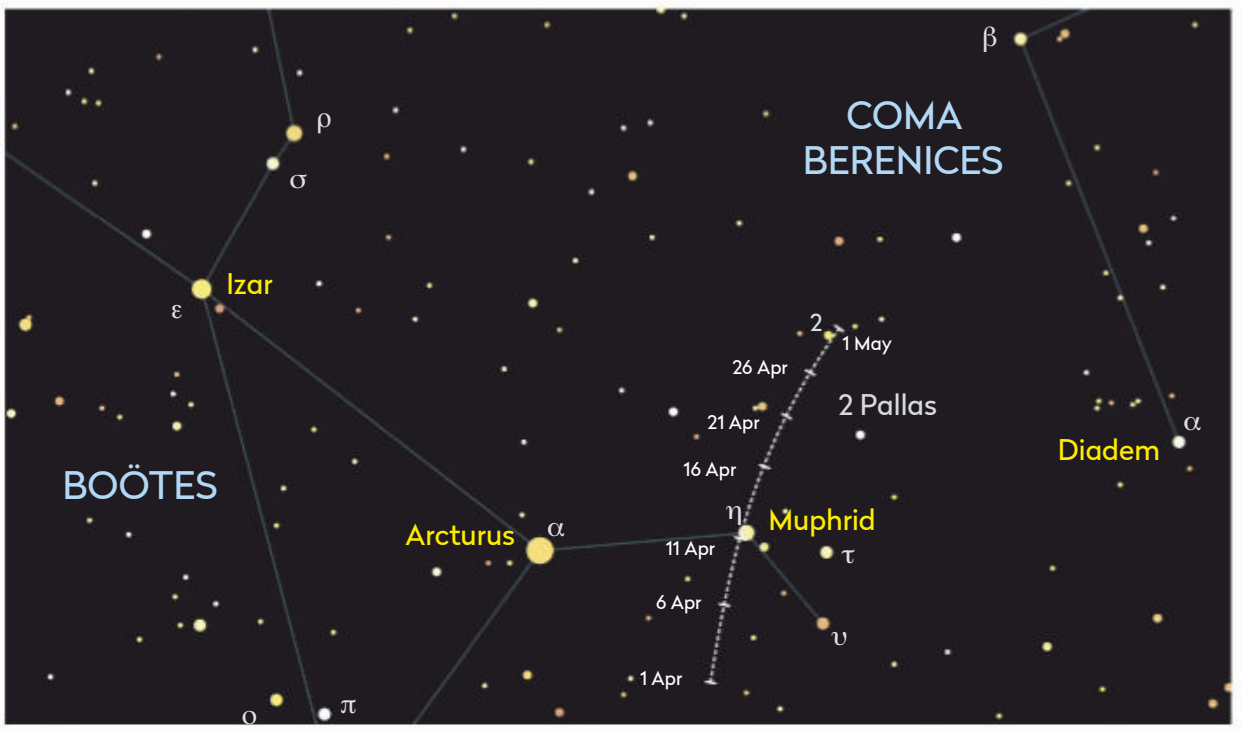
BEST TIME TO SEE: All month, with opposition on 10 April

Minor planet 2 Pallas reaches opposition on 10 April. At this time it appears as a mag. +7.9 dot moving slowly against the stars of the southern part of Boötes, not too far from the bright star Arcturus (Alpha (α) Bootis).

Pallas is a large asteroid with a mean diameter of 512km. It takes 4.62 years to orbit the Sun at an average distance of 2.8 AU. Interestingly, it was almost discovered by the French astronomer Charles Messier of Messier Catalogue fame. He recorded it on 5 April 1779 on a chart used for recording the position of comet C/1779 A1 Bode. He assumed it was a star at the time. It wasn't until 1801 that Pallas was formally discovered by Giuseppe Piazzi. Ironically, Piazzi thought Pallas was a comet.

On 1 April, Pallas appears 5° southwest of Arcturus. It then follows a path arcing to the northwest. Although it approaches the border with Coma Berenices on 30 April, it doesn't quite manage to cross over into this neighbour of Boötes.

A good opportunity to locate Pallas occurs on the night of 10–11 April when it passes very close to mag. +2.7 Muphrid



▲ **Minor planet 2 Pallas passes through southern Boötes in April, not far from bright Arcturus**

(Eta (ε) Bootis). At 01:00 BST (00:00 UT) on 11 April, Pallas will appear approximately 4 arcminutes northeast of the star. On the night of 29–30 April, Pallas will have moved further to the northwest to lie very close to the mag. +5.7 star 2 Bootis.

Being relatively bright and well located for viewing from locations all around the UK makes Pallas a good photographic target. One way to record its movement throughout the month is to take a shot which covers the southern half of Boötes over as many nights as possible. Aim for a magnitude depth of at least +9.0. Using an image editor, align the shots using the stars and layer them. Animating between frames will reveal Pallas by virtue of its apparent motion among the stars.

Jupiter moon show

BEST TIME TO SEE: Early morning on 4, 23 and 30 April



▲ **Three interesting Galilean moon transits visible this month (south is up in these diagrams)**

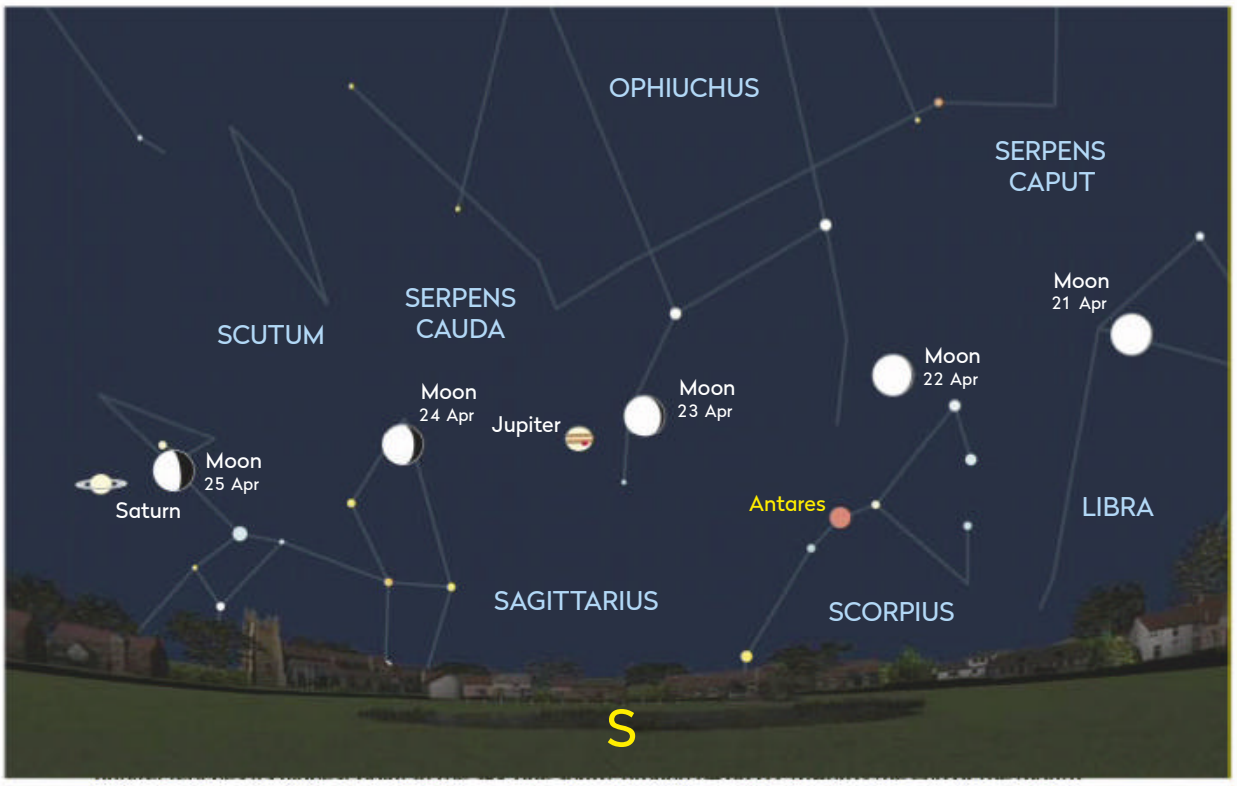
There are numerous interesting moon events on Jupiter this month. On the morning of 4 April, from 02:54 BST (01:54 UT) there is an opportunity to see the shadow of inner Galilean moon Io crossing Jupiter's disc. This will then be followed by a transit of Io itself starting at 04:05 BST (03:05 UT). If you have a planetary imaging setup which uses a mono high-frame-rate camera and you own an infrared pass filter, it's worth training this on Jupiter as Io transits. This hot moon shows up brightly against Jupiter's disc in infrared.

Then, on 23 April, a telescopic view of mag. –2.3 Jupiter at 02:10 BST (01:10 UT) will show the giant shadow of the moon Ganymede sitting on the north-south centreline of Jupiter's disc. Ganymede's shadow is especially prominent and will be fairly easy to see – even through a small telescope. At this time the planet will be 7° above the southeast horizon.

Finally, there's a second chance to spot Ganymede's immense shadow in transit on 30 April. This is a transit with a twist through because it doesn't start until 04:40 BST (03:40 UT) and continues into daylight. Start watching from 04:30 BST (03:30 UT) and see how long you can keep observing Jupiter and Ganymede's shadow transit as the sky brightens.

THE PLANETS

Our celestial neighbourhood in April



▲ **Jupiter outshines Saturn, as it joins its neighbour near the horizon in the morning sky**

PICK OF THE MONTH

Jupiter

Best time to see:
30 April, 03:45 BST (02:45 UT)
Altitude: 14°
Location: Ophiuchus
Direction: South
Features: Complex banded atmosphere, Galilean moons
Recommended equipment:
75mm scope or larger

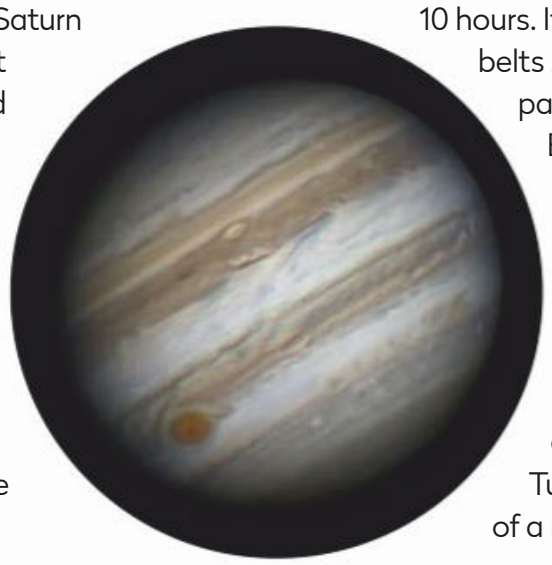
PETE LAWRENCE X 3

We are entering a difficult period for the gas giants in the UK. Saturn has been low for what seems like forever and Jupiter is joining it. During April, Jupiter is a dominant morning object balancing on the eastern knee of Ophiuchus the Serpent Bearer. From the centre of the UK it only manages a maximum altitude of 14° when due south.

The good news is that it does manage to do this under relatively dark skies towards the end of the month, and this will improve the contrast of any features visible. The bad news is down to the atmosphere. Close to the horizon, the layer of atmosphere you're looking through is thicker than at higher altitude. In addition, it tends to be more turbulent and this will cause any fine detail to become distorted and blurred.

While this is irksome for larger instruments, small telescopes can still fare well. Unable to reach the high magnifications that a larger telescope may reach, the effects of the atmosphere are less magnified too. The net result is a smaller, less detailed planet that doesn't look so affected by the atmosphere.

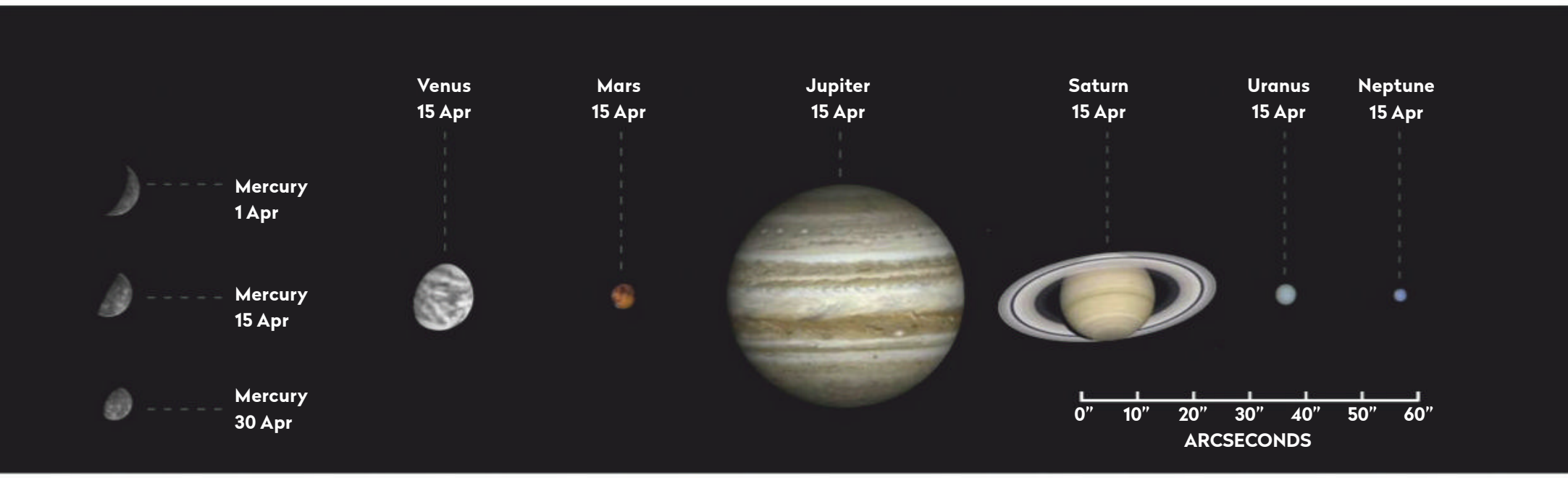
Using a small scope, Jupiter's oblate shape should be evident, an effect caused by this predominantly gaseous body rotating once on its axis in just less than 10 hours. Its main atmospheric belts should be visible too – in particular the North Equatorial Belt (NEB) and South Equatorial Belt (SEB). Then there are the trusty Galilean moons. These are fascinating to watch as they encircle the planet and cast their shadows on its atmosphere below. Turn to page 47 for details of a number of Galilean moon events during April. On 23 April an 84%-lit waning gibbous Moon lies 5° to the west of the planet.

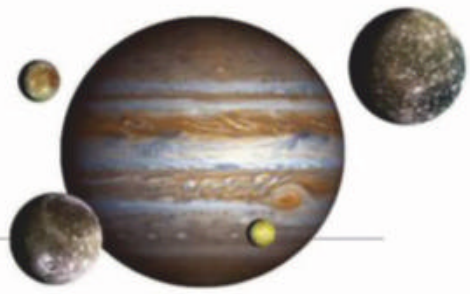


▲ **Viewing details on Jupiter may be affected by the thickness of our atmosphere**

The planets in April

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope





Mercury

Best time to see: 1 April, 20 minutes before sunrise
Altitude: 2° (very low)
Location: Aquarius
Direction: East

Mercury isn't particularly well placed in the morning sky this month. At mag. +0.9 on 2 April, it appears close to mag. –3.9 Venus and a 9%-lit waning crescent Moon. Greatest western elongation occurs on 11 April when Mercury is 27.7° west of the Sun. At mag. +0.3 on 15 April, Mercury is just 4.2° from Venus but again, low altitude doesn't do it any favours. The situation doesn't improve throughout April.

Venus

Best time to see: 1 April, 30 minutes before sunrise
Altitude: 2° (very low)
Location: Aquarius
Direction: East-southeast

At mag. –3.9, Venus is hard to miss in the morning twilight. Despite this, the planet is edging slowly south of the ecliptic and the shallow angle that this great circle makes with the eastern horizon means that its position before sunrise is compromised. The result is Venus rises close to sunrise. At the start of the month, it rises one hour before the Sun, dropping to half an hour by April's end. A 15%-lit waning crescent Moon approaches from the west on 1 April, appearing 3.4° below Venus on the morning of 2 April when its phase will have decreased to 9%. On 1 April Venus appears 81%-lit and 13 arcseconds across. By the end of the month, Venus will then appear 87%-lit and just 11 arcseconds across.

Mars

Best time to see: 1 April, 21:00 BST (20:00 UT)
Altitude: 29°
Location: Taurus
Direction: West

Mars spends the month in Taurus moving along a path southeast of the Pleiades and north of the Hyades clusters for the first 10 days of April. A thin 12%-lit waxing crescent Moon sits with Mars, the Pleiades and Hyades on 8 April – a great target for wide-field astrophotography. Having increased in phase to 19% on the evening of 9 April, the Moon's crescent will sit close to Aldebaran (Alpha (α) Tauri), providing a second opportunity for a group photo. Telescopically Mars is now disappointing: being distant from Earth, its disc only appears 4 arcseconds across through the eyepiece. To the naked eye Mars dims from mag. +1.5 to +1.6 over the month.

Saturn

Best time to see: 30 April, 01:00 BST (00:00 UT)
Altitude: 10.5°
Location: Sagittarius
Direction: Southeast

Saturn and Jupiter both grace the morning sky. At mag. –2.1, Jupiter outshines its mag. +0.9 neighbour. The lengthening days mean Saturn doesn't get a chance to get to its highest altitude before twilight. Any telescopic views will be compromised. A 67%-lit waning gibbous Moon lies 5.8° to the west of Saturn on the morning of 25 April, and 6.7° to the east of the planet on the morning of 26 April, when it'll be showing a 57%-lit waning gibbous phase. Saturn's tilt angle is decreasing. Currently it's the planet's northern pole which is tilted towards us by around 23.6°.

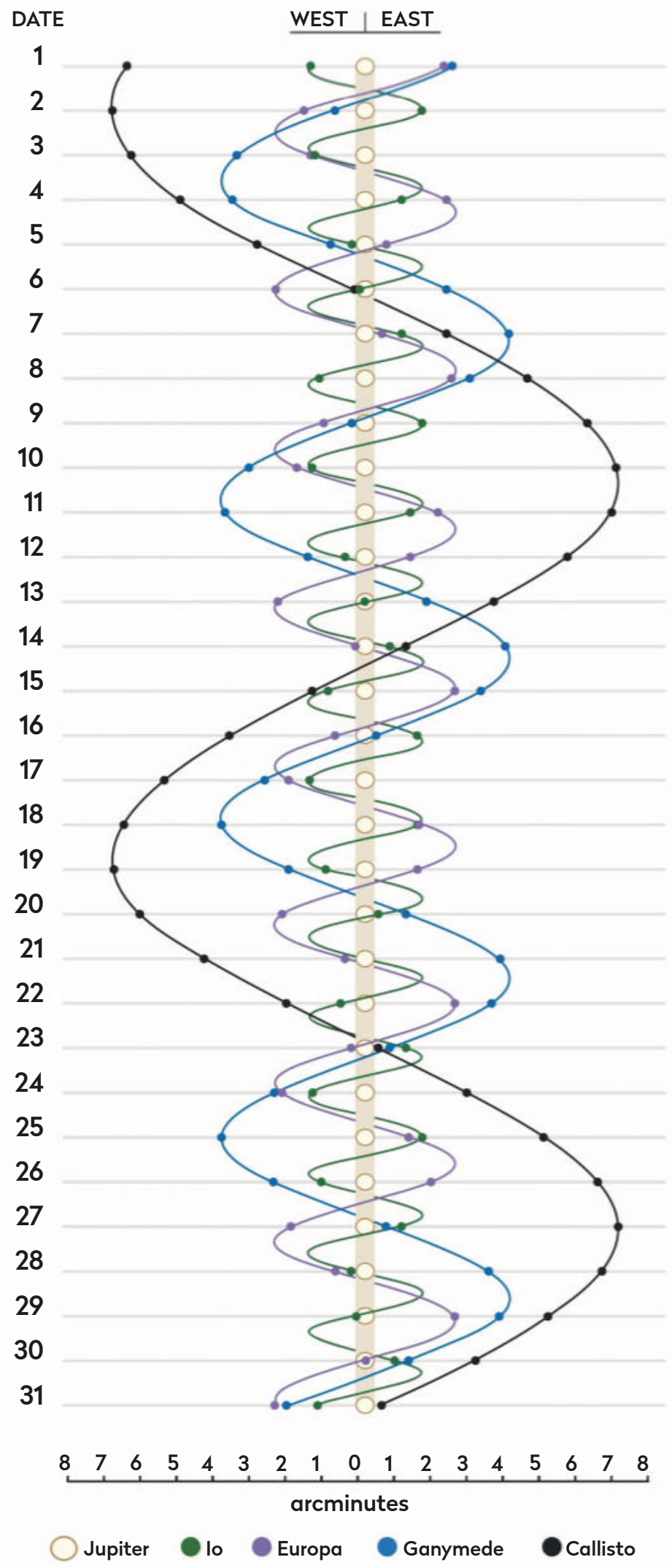
Not visible this month

Uranus, Neptune

More **ONLINE**
Print out observing forms for recording planetary events

JUPITER'S MOONS: APRIL

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



THE NIGHT SKY – APRIL

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Circlet — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- COMPASS AND FIELD OF VIEW
- MILKY WAY

When to use this chart

1 April at 01:00 BST
15 April at 00:00 BST
30 April at 23:00 BST

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.



Sunrise/sunset in April*



Date	Sunrise	Sunset
1 Apr 2019	06:44 BST	19:45 BST
11 Apr 2019	06:21 BST	20:03 BST
21 Apr 2019	05:58 BST	20:21 BST
1 May 2019	05:36 BST	20:39 BST

Moonrise in April*



Moonrise times

1 Apr 2019, 05:55 BST	17 Apr 2019, 17:31 BST
5 Apr 2019, 07:12 BST	21 Apr 2019, 22:59 BST
9 Apr 2019, 08:38 BST	25 Apr 2019, 02:12 BST
13 Apr 2019, 12:01 BST	29 Apr 2019, 04:24 BST

*Times correct for the centre of the UK

Lunar phases in April

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	2	3	4	5 NEW MOON	6	7
8	9	10	11	12	13	14
15	16	17	18	19 FULL MOON	20	21
22	23	24	25	26	27	28
29	30					

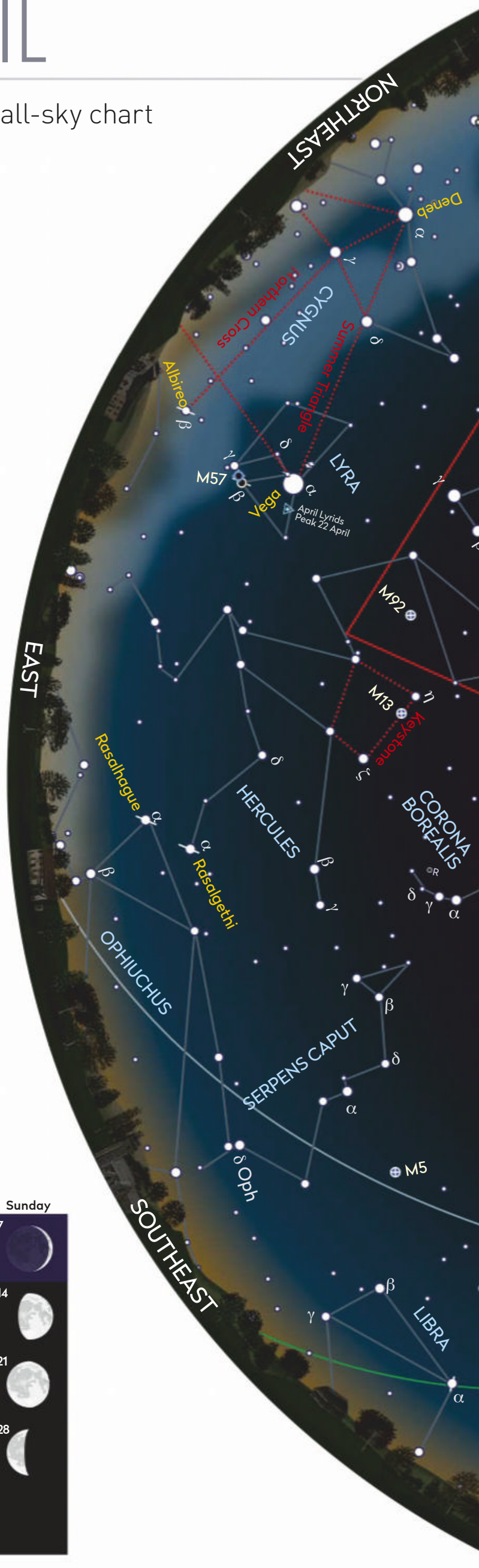


CHART: PETE LAWRENCE



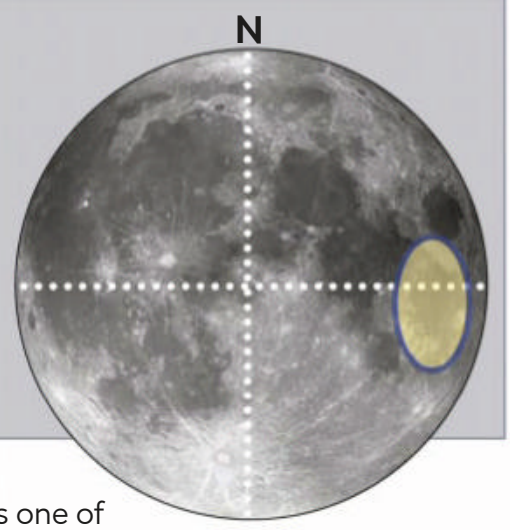
More **ONLINE**
Paul and Pete's Virtual Planetarium

MOONWATCH

April's top lunar feature to observe

Mare Fecunditatis

Type: Lunar sea
Diameter: 600x500km
Longitude/latitude: 53.7° E, 7.8° S
Age: Older than 3.9 billion years
Best time to see: Four days after new Moon (8–9 April) and three days after full Moon (21–22 April)
Minimum equipment: 10x binoculars



Mare Fecunditatis, the Sea of Fertility, is one of the main lunar seas. It is a huge, lava-filled impact basin measuring 600x500km, covering 325,000 square kilometres. In Earth equivalents, Mare Fecunditatis is not dissimilar in area to the Caspian Sea, the largest enclosed inland body of water on our planet. The Caspian Sea measures 1,030x435km and covers an area of 371,000 square kilometres.

"The dark, diamond-shaped Mare Fecunditatis is visible to the naked eye and easily recognised"

The dark, somewhat diamond-shaped, patch that represents Mare Fecunditatis is visible to the naked eye and easily recognised as it marks the southeast end of a progression of large lunar seas running from Mare Serenitatis, through Mare Tranquillitatis and into Fecunditatis. It also lies south of the distinctive oval sea known as Mare Crisium.

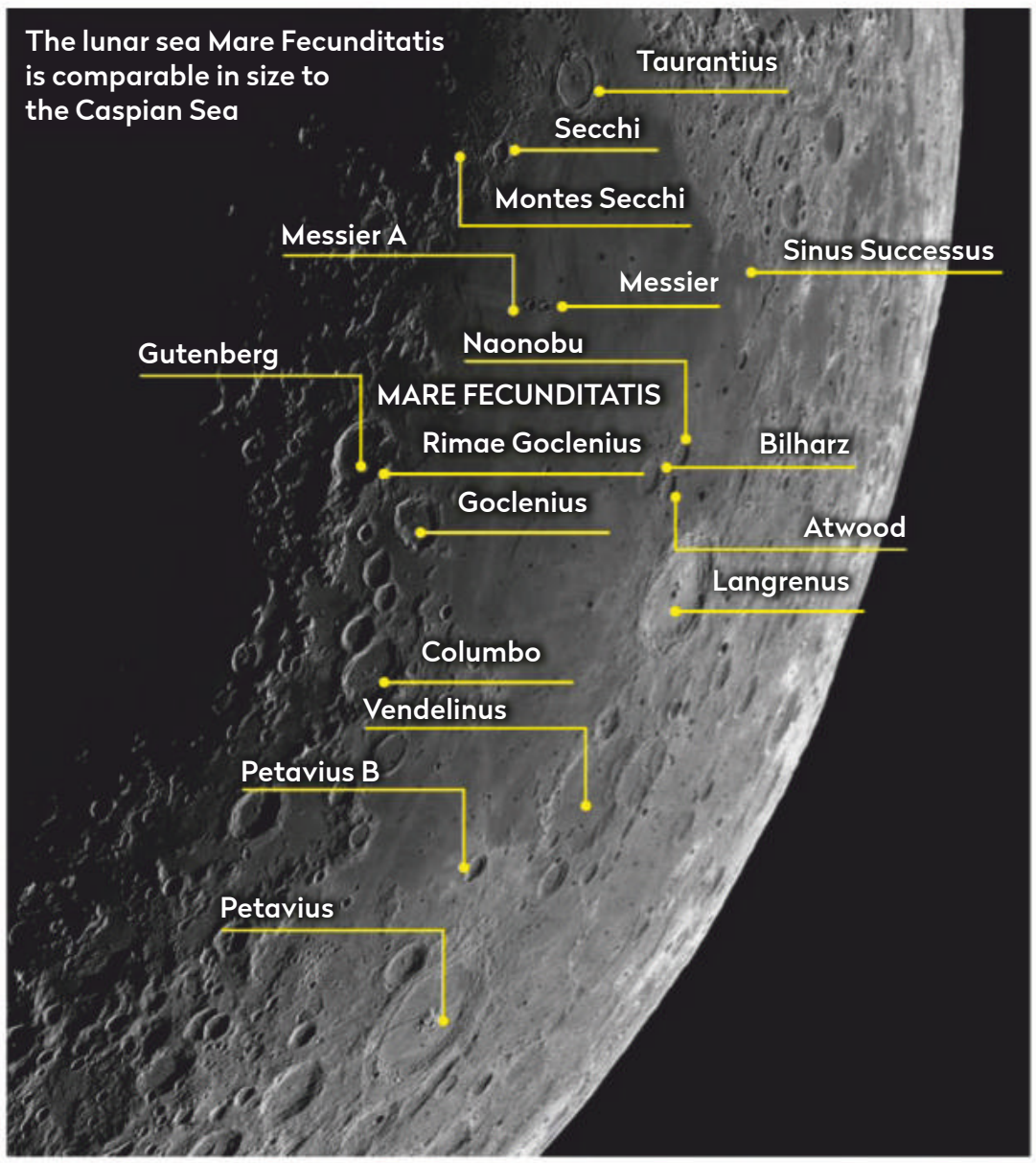
Being large, it's not surprising that there are many interesting features that lie within and border the sea. The surface of Fecunditatis is dark with lighter streaks. One major source of these streaks is the impressive 133km crater **Langrenus**, which sits on the eastern edge of the mare. Ejecta rays can be seen crossing a large portion of Fecunditatis, especially under high illumination in the southern part of the mare.

A distinctive triplet of smaller craters lies to the northwest of Langrenus, on Fecunditatis's floor. These are 35km Naonobu, 43km Bilharz and 30km Atwood. All three are quite similar in appearance, with flat floors. The complex eastern edge of Mare Fecunditatis has an irregular bay towards the north. This is the 100km **Sinus Successus**. The edge of the mare then becomes more defined as it angles northwest toward 56km Taurantius.

The northwestern border is defined by **Montes Secchi**, with the 25km crater Secchi embedded within. It then becomes irregular once more as it heads south towards a region dominated by 75km Gutenberg, 55km Goclenius and 76km Colombo. The western edge is interesting because it contains a number of bow-shaped rilles. These are mostly grabens – regions of the lunar surface that have dropped between fault lines. They appear to follow the curvature of the edge of Fecunditatis concentrically. The most prominent are known as **Rimae Goclenius**, with the most impressive example extending northwest from Goclenius. Careful examination will show the graben passing diagonally across its entire width.

The southern end of Mare Fecunditatis is less well defined but delineated by the irregular 147km crater **Vendelinus** to the southeast. The 33km crater **Petavius B** interferes with the mare's floor, with additional light ray features spreading west from the crater.

Two small yet well-known craters situated in the northwest portion of the mare are **Messier** and **Messier A**. Messier is the smaller of the two at 12x9km. It lies to the east of 13x11km Messier A. While Messier has a distinctly oval shape, Messier A appears more rounded with a double lip to the west. A pair of lighter rays appears to spread out from Messier A towards the western shore of Fecunditatis. Under high illumination two further sprays of lighter material can be seen heading north and south of Messier for quite some distance.



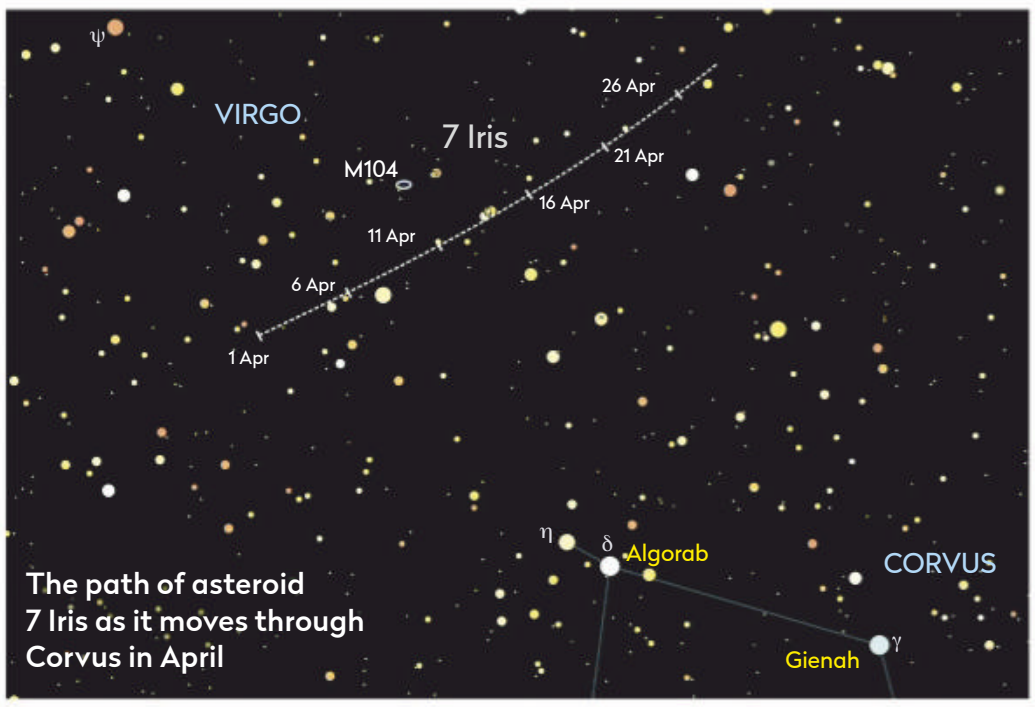
PETE LAWRENCE X 5

COMETS AND ASTEROIDS

Look to Corvus to catch stony 7 Iris, the fourth brightest object in the asteroid belt

Asteroid 7 Iris reaches opposition on 5 April in the northern regions of Corvus, approximately 1.5° to the southeast of the mag. +8.3 edge-on spiral galaxy M104, the Sombrero Galaxy. Iris will shine at mag. +9.4 from 1 to 11 April, slowly dimming to +9.9 by the end of the month. This places it within easy reach of a small telescope. At opposition, Iris will be 1.83 AU from Earth. Throughout the month it slowly creeps towards the northwest passing across the border from Corvus and into Virgo on 17 April.

Iris was discovered by the English astronomer John Russell Hind on 13 August 1847. It is a main belt asteroid, one of many hundreds of thousands of such bodies which orbit the Sun between Mars and Jupiter. It's a siliceous or S-type asteroid, which means its composition is mineralogical or stony. Such bodies are relatively bright and Iris is the fourth brightest asteroid in the main belt. As oppositions go, this one is relatively poor and well below its mean opposition magnitude of +7.8.



The path of asteroid 7 Iris as it moves through Corvus in April

Iris takes 3.68 years to compete one orbit around the Sun. At aphelion it is 2.94 AU from the Sun, a distance that diminishes to 1.83 AU at perihelion. Its mean distance is 2.34 AU. Iris is a sizeable object with dimensions of 240x200x200km. Albedo measurements show a periodic fluctuation suggesting that its nickel-iron, magnesium and iron-silicate surface is brighter in the northern hemisphere.

The shape of Iris was investigated using Doppler radar via the Arecibo radio telescope in Puerto Rico in 2006. This investigated the asteroid's high southern latitudes and showed a complex surface with three roughly 50km diameter concave features, presumably impact craters, virtually equally spaced around the southern pole.

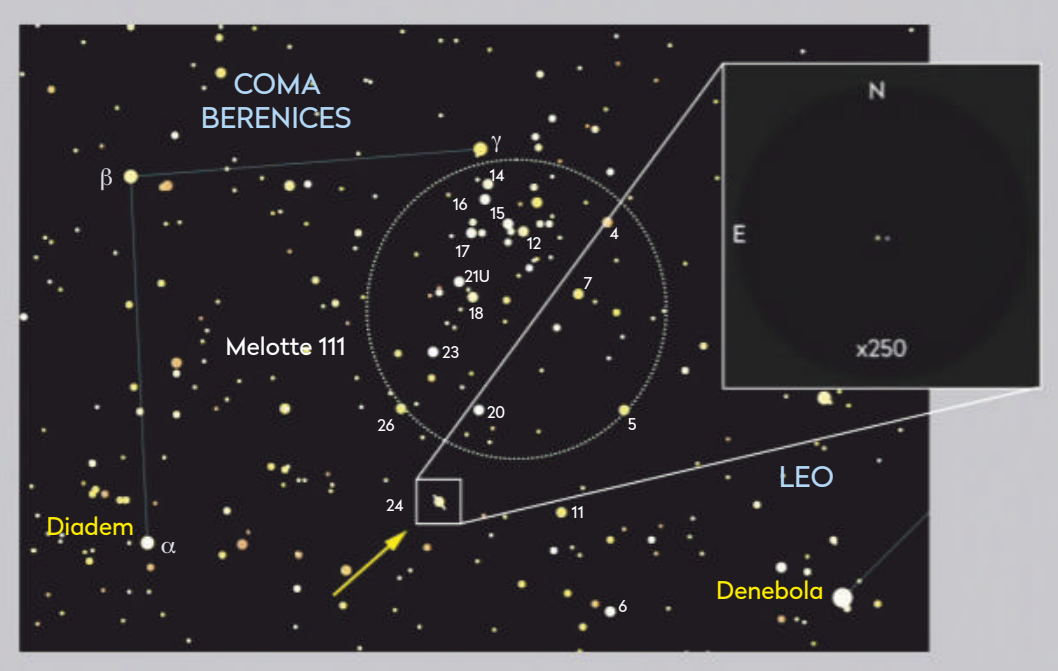
STAR OF THE MONTH

24 Comae Berenices, spring's hidden treasure

Located in a rather tricky part of the sky to navigate, just south of the open cluster Melotte 111, there are a couple of ways to find the stunning double star 24 Comae Berenices. Imagine the mid-point between Denebola (Beta (β) Leonis) and Diadem (Alpha (α) Comae Berenices). Nudge slightly towards Diadem and look 1.8° to the north to locate 24 Comae. It can also be found two-thirds of the way between Porrima (Gamma (γ) Virginis – not shown) and Gamma Comae Berenices.

This is a beautiful pair of stars, formed from a yellow-orange, K0, mag. +5.2 primary separated by a little over 20 arcseconds from a blue-white, A3, mag. +6.7 secondary. The position angle is about 280°. The primary is 590 lightyears away, with the secondary 2,600 lightyears away, making this an optical line of sight double star rather than a true binary.

A small telescope will show them, but mid to large apertures are required to make their colours stand out. The contrast between both stars' colours is what makes the view so sublime, each providing a basis for comparison with the other. Their yellow-orange and blue-white colour combination



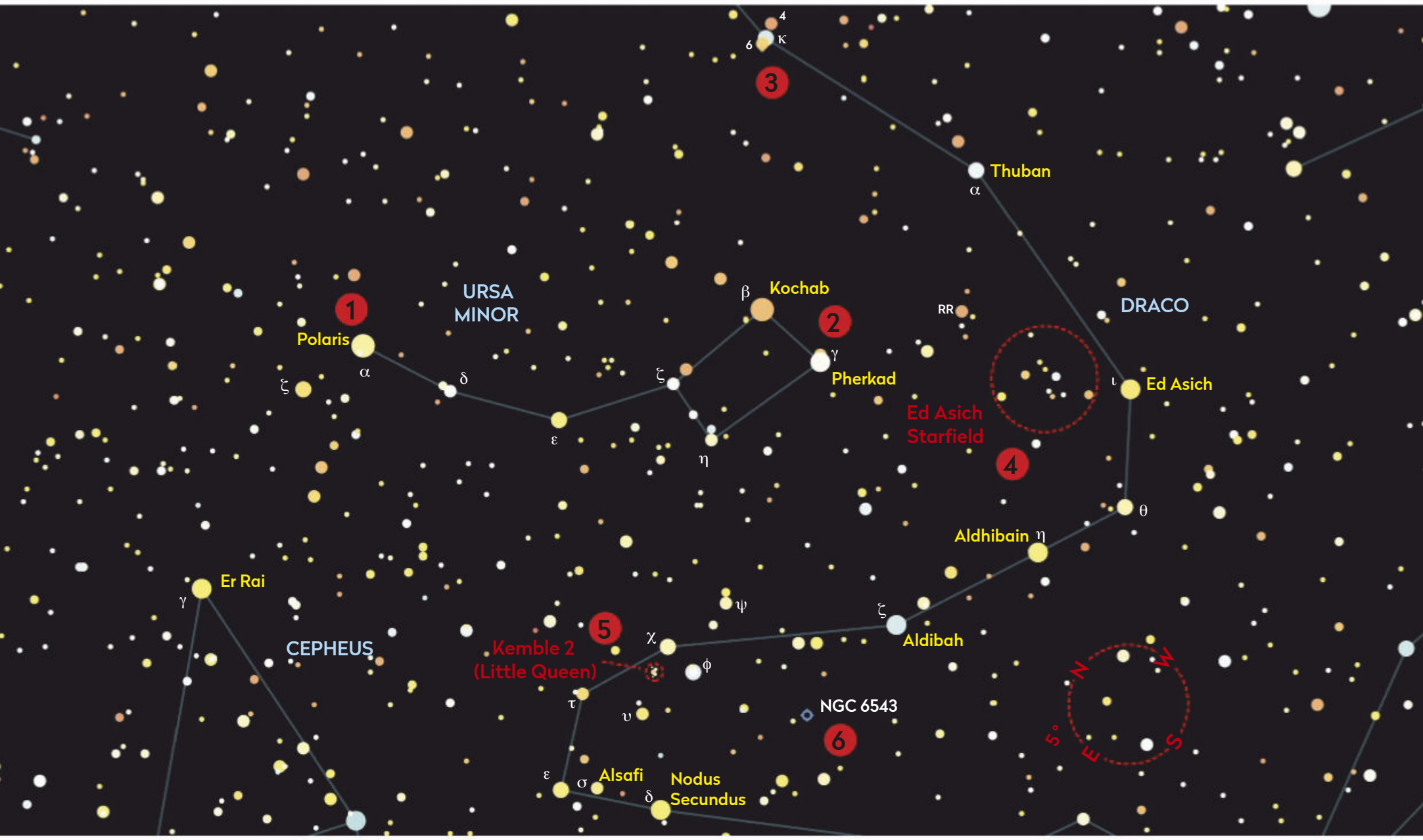
▲ **The double star's gem-like colours make a wonderful contrast**

draws further comparison with that heavenly gem, Albireo (Beta (β) Cygni), the jewel in summer's crown. As a consequence, 24 Comae Berenices is often described as 'spring's Albireo'. It's quite similar in appearance to Albireo, albeit dimmer and with slightly less colour contrast.

BINOCULAR TOUR

With Stephen Tonkin

Two celestial poles, and double and triple stars are among April's wide-field highlights



1 Polaris 'engagement ring'

We binocular observers have an advantage here: our wide field of view reveals that Polaris (Alpha (α) Ursae Minoris) blazes like the solitaire diamond in a kinked ovoid ring of 8th and 9th-magnitude stars. Notice that the kink is a star that is slightly displaced towards Polaris. The next star anticlockwise on the ring gives us a more precise way of locating the North Celestial Pole (NCP), which is the same distance from Polaris on the opposite side. ☐ **SEEN IT**

2 Guardians of the Pole

The next brightest stars in Ursa Minor are the southernmost stars of the Little Dipper asterism, orange Kochab (Beta (β) Ursae Minoris) and brilliant white Pherkad (Gamma (γ) Ursae Minoris), traditionally designated the 'Guardians of the Pole'. Pherkad is an easy double with 5th-magnitude pale orange Pherkad Minor (Gamma-1 (γ1) Ursae Minoris), 17 arcminutes to the west. ☐ **SEEN IT**

3 Kappa Dra group

An attractive line of coloured stars, the brightest of which is blue-white Kappa (κ) Draconis which is more than 500 times as luminous as the Sun. To the north are two orange (spectral type K) stars; the brighter one is 6 Draconis, a little more than half as luminous as κ Dra. The line's most southerly star is ruddy 4 Draconis, a long-period pulsating variable (mag. +4.9 to +5.0) that has a similar luminosity to 6 Dra. ☐ **SEEN IT**

4 Ed Asich starfield

Ed Asich is not an obscure astronomer, but one of the names of Iota (ι) Draconis. Just to the north of it is a poleward-pointing group of 6th- and 7th-magnitude stars that extends for about 3°. Spend some time examining it and you'll be rewarded: there are several binocular double and triple stars, and colours ranging from orange to blue. Go north towards Pherkad, where you will find another group of stars that includes the orange-red RR Umi. ☐ **SEEN IT**

5 Kemble 2

To find this mini Cassiopeia-like asterism, first locate Chi (χ) Draconis. In the same field of view, 1° towards Alsafi (Sigma (σ) Draconis), you'll see a triangle of 7th-magnitude stars. Either side of the star at the apex nearest Tau (τ) Draconis you will see a pair of fainter stars that complete a trapezium of which the triangle is a part, forming a 'W' with fainter tips. ☐ **SEEN IT**

6 NGC 6543

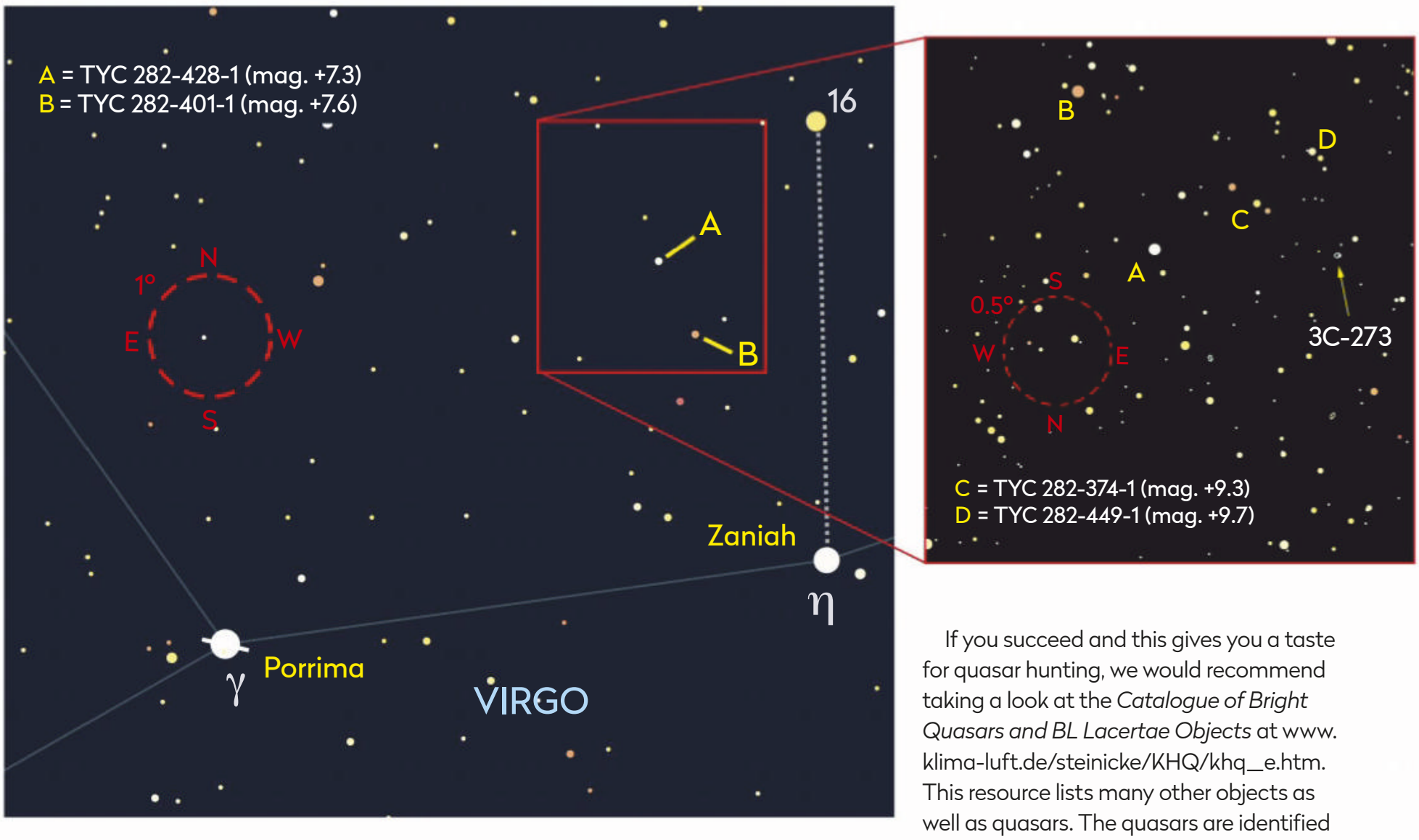
NGC 6543, the Cat's Eye Nebula, marks the position of the North Ecliptic Pole, that point on the northern celestial hemisphere that is always the same angular distance from the Sun – the centre of the circle that the NCP makes in its precessionary cycle. NGC 6543 is offset a degree towards Aldhibah from the centre of a line joining Nodus Secundus (Delta (δ) Draconis) to Aldhibah (Zeta (ζ) Draconis). ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

THE SKY GUIDE CHALLENGE

This month we are hunting for quasars, objects from the dim and distant past



▲ The first task is to locate the stars labelled A and B (above) in Virgo. Next, look out for stars C and D (right) to form a right-angled triangle with quasar 3C 273

A favourite question of quizmasters is "What's the furthest object that you can see with the naked eye?". The answer invariably given is the Andromeda Galaxy, M31, which – at 2.5 million lightyears away – is impressively distant. However, as with many things in astronomy, there are instances where this might be beaten. Under very dark skies, the Triangulum Galaxy, M33, may be seen. Its distance is less certain, quoted as 2.4–3.1 million lightyears, but at the latter value it would easily beat M31. There have even been claims that the galaxies M81 and M82 in Ursa Major have been seen from exceptional sites at high altitude. At a distance of 11.7 million lightyears, these would be hard to beat.

So what about with a telescope? Here things get much more complex, as different sizes of telescope have different light-grasp capabilities. Combined with variable sky conditions, looking for distant targets can produce markedly different results. One of the best targets for this kind of exercise is an object known as a quasar. A quasar is a distant star-like object, the name quasar being a contraction of 'quasi-stellar', meaning 'star-like'. They are believed to be extremely luminous active galactic nuclei, possibly powered by a super-massive black hole.

"The light from quasar 3C 273 set off 2.4 billion years ago – roughly half the age of our Sun."

Most are pretty faint, but there are a number which are within the visual range of amateur telescopes. A classic example visible at this time of year is 3C 273, located in Virgo. This is one of the first quasars identified as such and shines away at mag. +12.9. If you manage to locate it, the light from this object set off 2.4 billion years ago – roughly half the age of our Sun. Use our finder chart and see if you can find 3C 273 visually.

If you succeed and this gives you a taste for quasar hunting, we would recommend taking a look at the *Catalogue of Bright Quasars and BL Lacertae Objects* at www.klima-luft.de/steinicke/KHQ/khq_e.htm. This resource lists many other objects as well as quasars. The quasars are identified in the table by the abbreviation QSO.

Distances are listed in terms of redshift (z). This value is a way of determining an object's distance at cosmological scales. Redshift indicates how much an object's spectrum has been shifted towards the red end of the spectrum, a consequence of the speed it is moving away from us. Redshift is given as $v \div c$ where v is the velocity (km/s) and c the speed of light (299,792km/s). Once you have worked out redshift, you can work out the distance of the object in megaparsecs (Mpc) using the formula $v \div H_0$, where H_0 is the Hubble Constant (the unit of measurement for describing the expansion of the Universe). A precise value for the Hubble Constant hasn't been settled on, but a value of 67km/s/Mpc can be assumed. Rearranging these formulae allows us to determine distance from redshift as $zc \div H_0$.

DEEP-SKY TOUR

From globular clusters in Hercules, to the Cat's Eye Nebula and remote Draco galaxies

1 M92

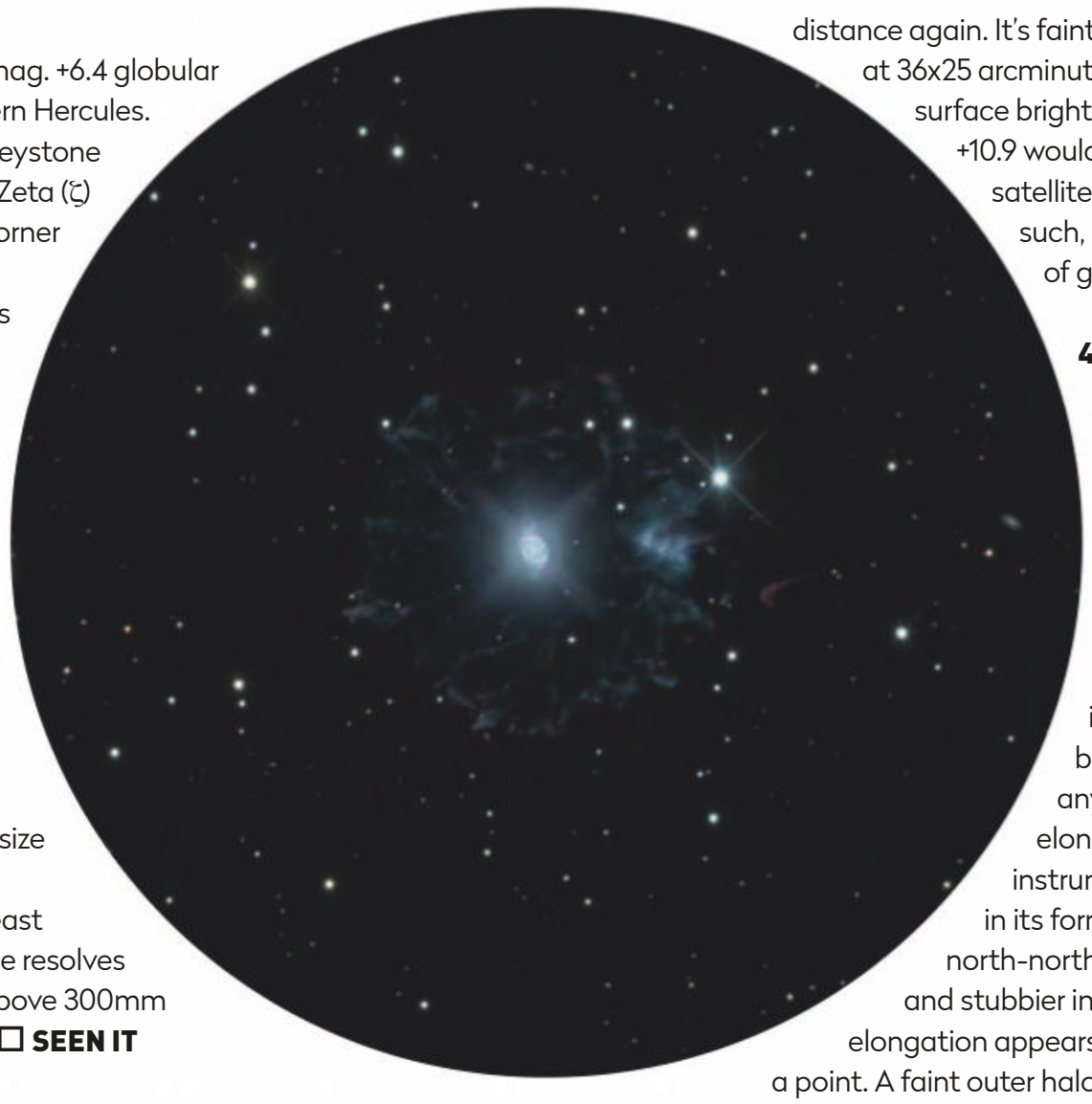
Messier 92 is a mag. +6.4 globular cluster in northern Hercules. It can be found using the Keystone asterism. Draw a line from Zeta (ζ) Herculis in the southeast corner of the pattern through the mid-point of the Keystone's top edge. Keep going a fraction less than the same distance again to arrive at M92. An obvious comparison is with the famous Great Globular in Hercules, M13. M92, however, shows greater overall concentration. It transitions smoothly from faint outer stars, rising in brightness to its core. M92 appears 9x6 arcminutes in size through a 250mm scope, flattened along the southeast edge. While a 150mm scope resolves the outer stars, anything above 300mm should resolve everything. ☐ **SEEN IT**

2 NGC 6229

NGC 6229 is another globular cluster in Hercules. It lies 7° northwest of M92, just east of the mid-point joining 42 and 52 Herculis. Although NGC 6229 is a globular cluster, its appearance is very different to M92. It's fainter at mag. +9.4 and much smaller. Its core stands out well with a 200mm instrument. Averted vision should bring out some of the outer halo too at 60x magnification. A 250mm scope shows an object fractionally smaller than an arcminute in size which exhibits an unconvincingly resolved appearance. This is echoed with a 300mm scope, the granular texture of the globular being obvious but with no distinct star resolution. ☐ **SEEN IT**

3 Draco Dwarf

Seeing the Draco Dwarf is a deep-sky challenge, as it requires a large aperture and very dark skies. If this isn't within your grasp visually it makes a good photographic challenge too. The area containing this low surface brightness spheroidal galaxy can be found by extending a line from Iota (ι) Herculis through Rastaban (Beta (β) Draconis) for about 90% of that distance again. It's faint because it appears large at 36x25 arcminutes. This gives it a low surface brightness, less than its mag. +10.9 would suggest. This is a satellite of our Milky Way and, as such, is part of the Local Group of galaxies. ☐ **SEEN IT**



▲ NGC 6543, also known as the Cat's Eye Nebula, is 3,300 lightyears from Earth. A 300mm scope will pick out the inner detail

4 NGC 6543

NGC 6543 is a lot easier to see, a mag. +8.1 planetary nebula known as the Cat's Eye Nebula. It's located 3° west-northwest of mag. +4.8 42 Draconis. A 150mm instrument shows it clearly but is unlikely to reveal any detail other than its elongated nature. A 250mm instrument hints at asymmetry in its form. It appears elongated north-northeast to south-southwest and stubbier in the north. The southern elongation appears to taper off to more of a point. A faint outer halo, about 20 arcseconds across, surrounds a brighter inner region. A 300mm scope reveals inner detail, including the delicate arcs of material visible within the core. ☐ **SEEN IT**

5 NGC 6503

Next is a mag. +10.2 galaxy known as NGC 6503. It lies 1.7° to the northeast of mag. +4.8 Omega (ω) Draconis. This is a dwarf spiral galaxy (classification SA(s)cd) located at a distance of 18 million lightyears. It's estimated to be 30,000 lightyears across and appears tilted almost edge-on to us. Unlike the Draco Dwarf, NGC 6503 has a high surface brightness and can be seen through a 150mm telescope as an elongated patch of light with a bright centre and an apparent size of 3.0x0.8 arcminutes. Large instruments show the core to be offset and inclined differently to the outer halo. ☐ **SEEN IT**

6 NGC 6340

NGC 6340 is another galaxy in Draco and is a small, faint object listed at mag. +11.0. It sits 2.5° to the west of Psi (ψ) Draconis. NGC 6340 can be detected with smaller instruments but without much detail. A mag. +11.2 star sits 2 arcminutes to the northwest of the galaxy, itself accompanied by a mag. +12.8 star nearby. A 250mm instrument reveals the galaxy's bright elongated central core. A 300mm scope hints at arms wrapped around the bright but non-stellar nucleus. The wide oval shape of the galaxy is plain to see. ☐ **SEEN IT**

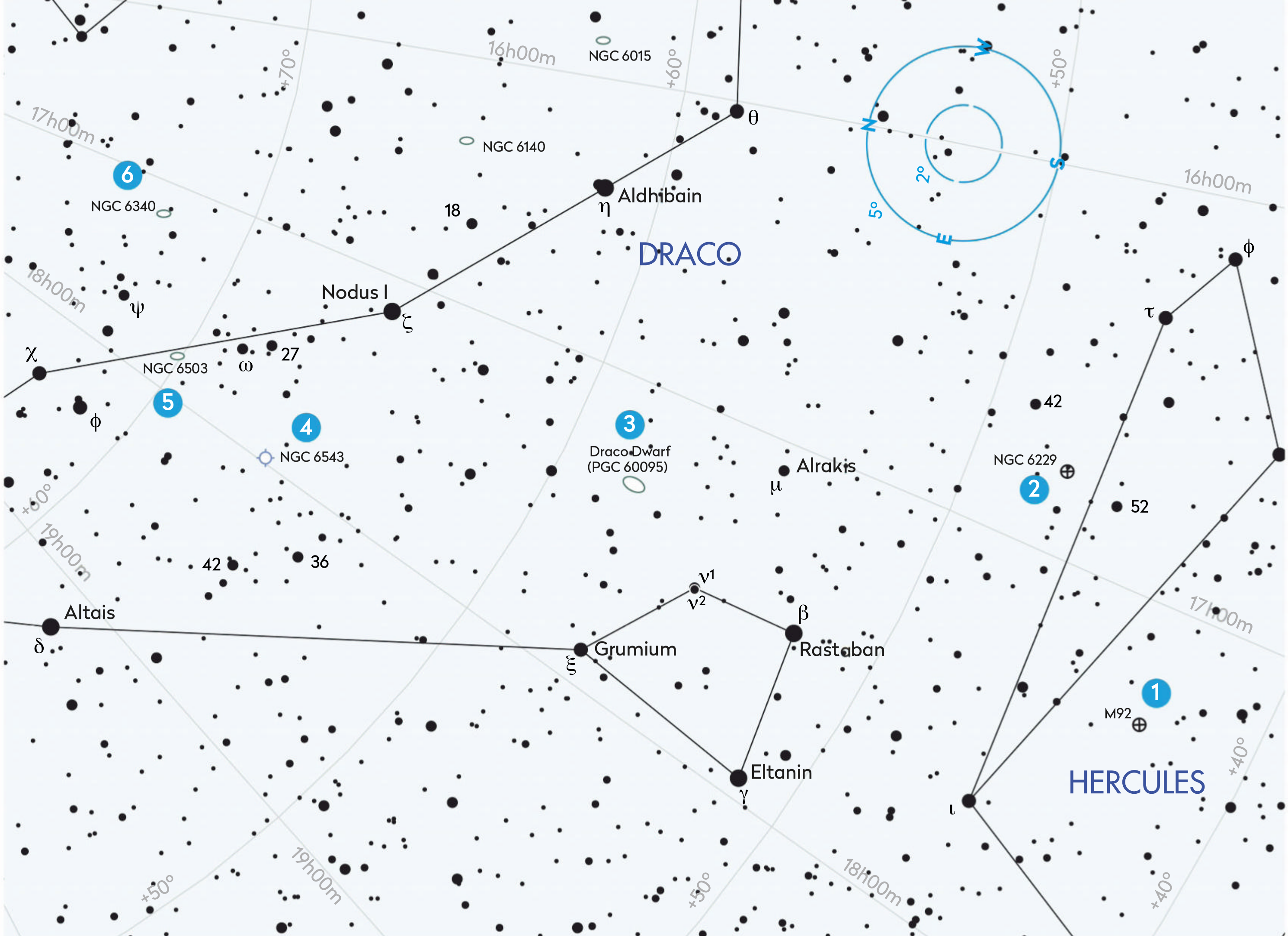
MARTIN RUSTERHOLZ/CCDGUIDE.COM, CHART BY PETE LAWRENCE

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.



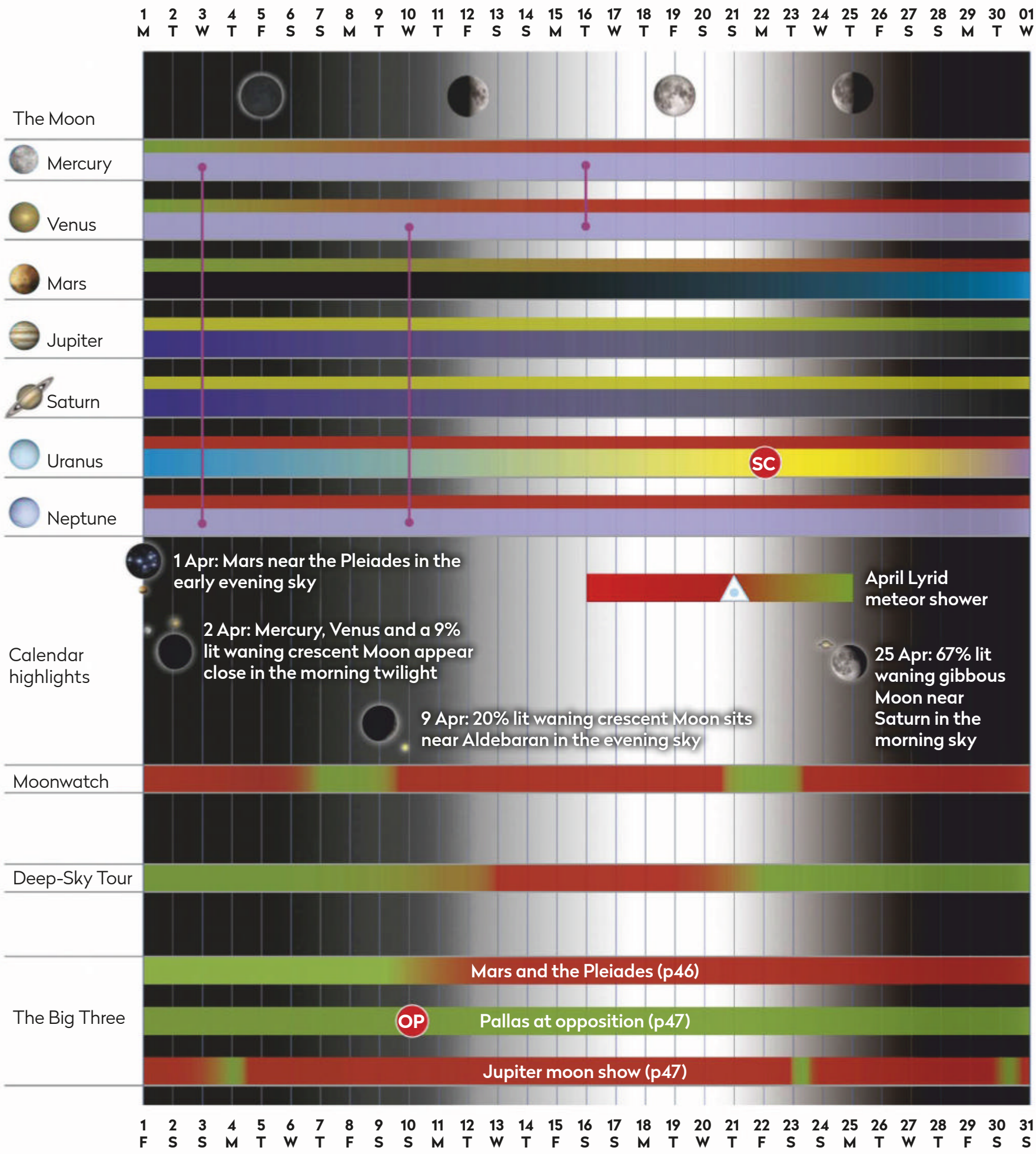
More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions.


16h00m
+70°
+60°
+50°
17h00m
18h00m
19h00m
NGC 6015
NGC 6140
NGC 6340
NGC 6503
NGC 6543
Draco Dwarf
(PGC 60095)
NGC 6229
M92
θ
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Aldhibain
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DRACO
Nodus I
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27
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AT A GLANCE

How the Sky Guide events will appear in April



KEY

Observability

Optimal | Poor

Best viewed

Morning twilight | Daytime | Evening twilight | Night

Sky brightness during lunar phases

Dark (first quarter) | Light (full Moon) | Dark (last quarter) | Total darkness (new Moon)

- IC — Inferior conjunction (Mercury & Venus only)
- SC — Superior conjunction
- OP — Planet at opposition
- Meteor radiant peak
- Planets in conjunction
- Full Moon
- First quarter
- Last quarter
- New Moon

CHART BY PETE LAWRENCE

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The fundamentals of astronomy for beginners

EXPLAINER

Fighting light pollution

Take action to stop unwanted glare affecting your stargazing



The constant glow of light pollution drowns out the beauty of dark skies for many

A truly dark sky is breathtaking, but the sad reality is that few of us have easy access to such skies, as our nights glow with the reflected light of thousands of streetlamps.

Astronomers have long been advocating for darker skies and for a reduction in light pollution. Other voices have recently been added to ours, with environmentalists, ecologists and healthcare professionals recognising the importance of a natural day–night cycle that includes darkness.

Around the British Isles, protected Dark Sky Parks (www.darkskydiscovery.org.uk) are springing up in places where great efforts have been made to combat skyglow. But while these sanctuaries of darkness are valuable and important, they are not always convenient places to visit.

So what can be done in our local streets and parks to help reduce light pollution? Are there practical steps we can take to make our local skies darker?

Luckily, excessively bright light at night is covered as a statutory nuisance in the same way as noise. Under the Clean Neighbourhoods and Environment Act 2005, any artificial light may be reported if it is considered "prejudicial to health or a nuisance". Knowing you have the law on your side is important, but this should be a last resort only if you've explored all other avenues.



▲ Millions turn off their lights for Earth Hour, but you can help to make your local skies permanently darker

Arm yourself with info

First and foremost, it's about education. Educate yourself in the various forms of light pollution and then spread the word in your community about the benefits of dark skies. Start with your local amateur astronomy society, and work to identify the places in and around your community that are best for stargazing. Keep an eye open for developments that might threaten those darker sites. It's easier to raise awareness of good street lighting at the planning stage than it is to seek improvements after bad lighting has been installed.

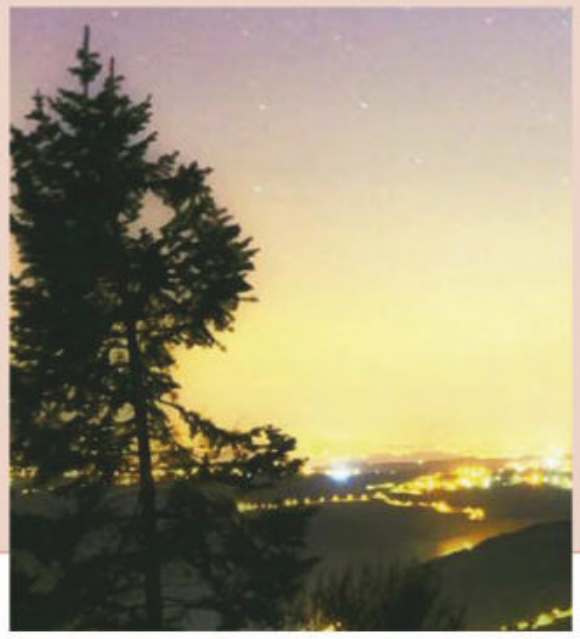
Learn to muster your arguments, and make sure you have evidence to back them up. If you attend

ISTOCK X 2, ANDREW WHYTE, STEVE MARSH, DAVID GEE/ALAMY STOCK PHOTO

Three types of light pollution

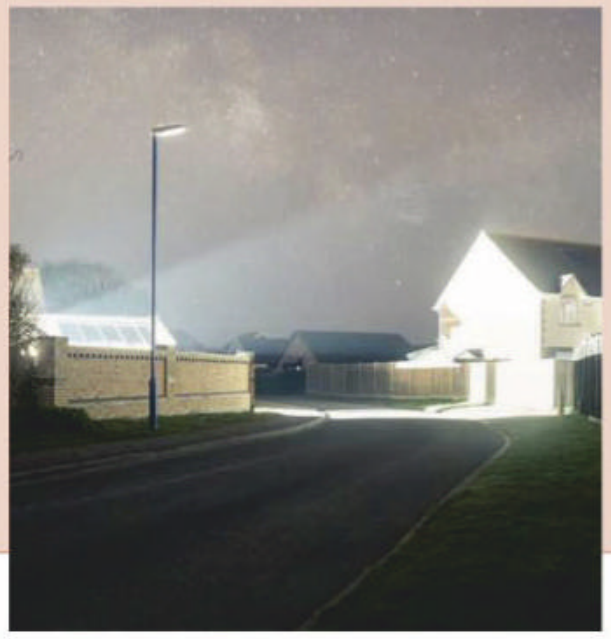
SKYGLOW

Familiar to all urban stargazers, this is the glow from streetlights reflected back down to Earth, drowning out light from fainter stars.



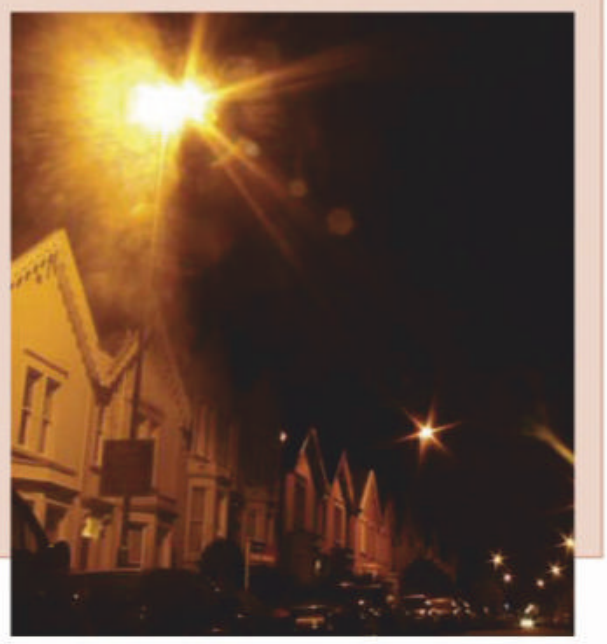
LIGHT TRESPASS

This could be a streetlight shining into your bedroom or a neighbour's security light coming on: light from any source that shines where it's not wanted.



GLARE

Bright light sources can spoil your night vision – annoying for stargazers, but also dangerous, as it can dazzle drivers and cause accidents.

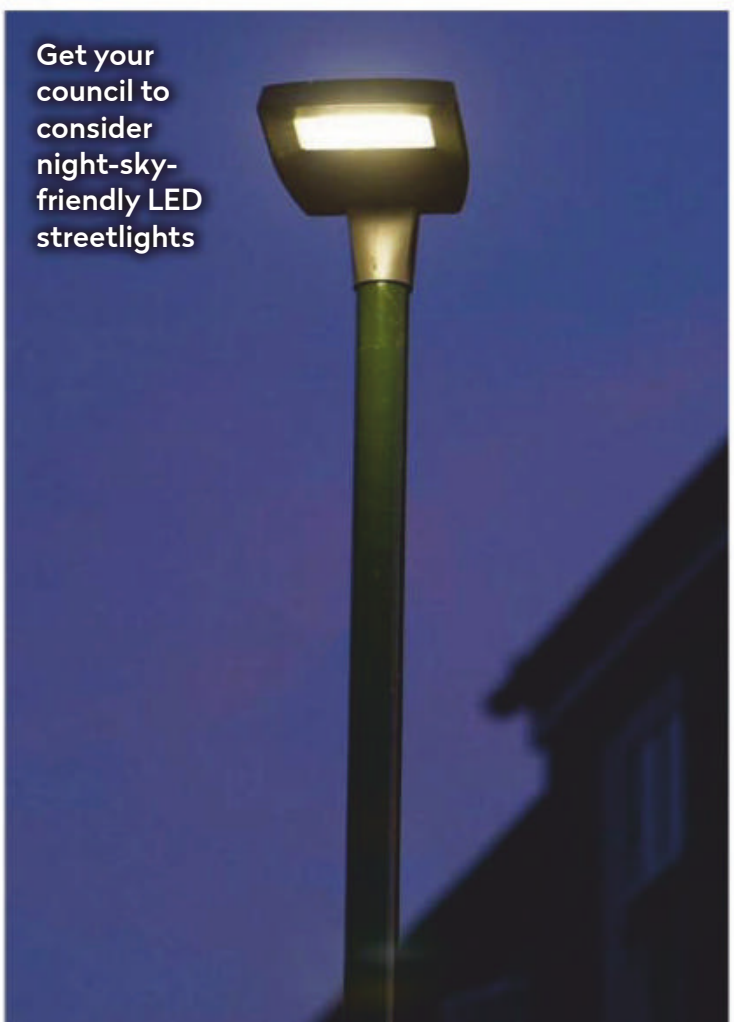




Steve Owens is a dark skies campaigner, On Tour Manager at Glasgow Science Centre and author of *Stargazing for Dummies*

public consultations and present this information clearly to developers, you might be surprised how receptive they are. The British Astronomical Association's Commission for Dark Skies has a fantastic online resource of evidence to back up your assertions (www.britastro.org/dark-skies).

Another great way to get the message across is to work with your local community council and amateur astronomy society to put on public stargazing events. Such events help bring your community together, and they are platforms where you can raise the issues of local light pollution. Most people are oblivious to bad lighting, and a little gentle education can go a long way.



Get your council to consider night-sky-friendly LED streetlights

Larger stargazing events may even have a demonstrable economic benefit to your community. Galloway Forest and Northumberland National Park – both protected Dark Sky Parks – have shown that astronomy tourism is an important economic driver in rural areas, and their local councils have adopted lighting policy that further protects their valuable dark sky asset.

While local examples of poor lighting can be addressed to the individuals or businesses responsible, skyglow is best tackled at the council level. Councils are legally obliged to consult on their local development plans; in conversation with council planners and lighting engineers you should stress the need for less wasteful lights that have zero 'upward' light. Developers or planners may not listen to astronomers complaining about vanishing stars, but they will pay attention when you explain that night-sky-friendly lighting is cheaper, produces less carbon dioxide, is better for wildlife and for human health, and is safer.

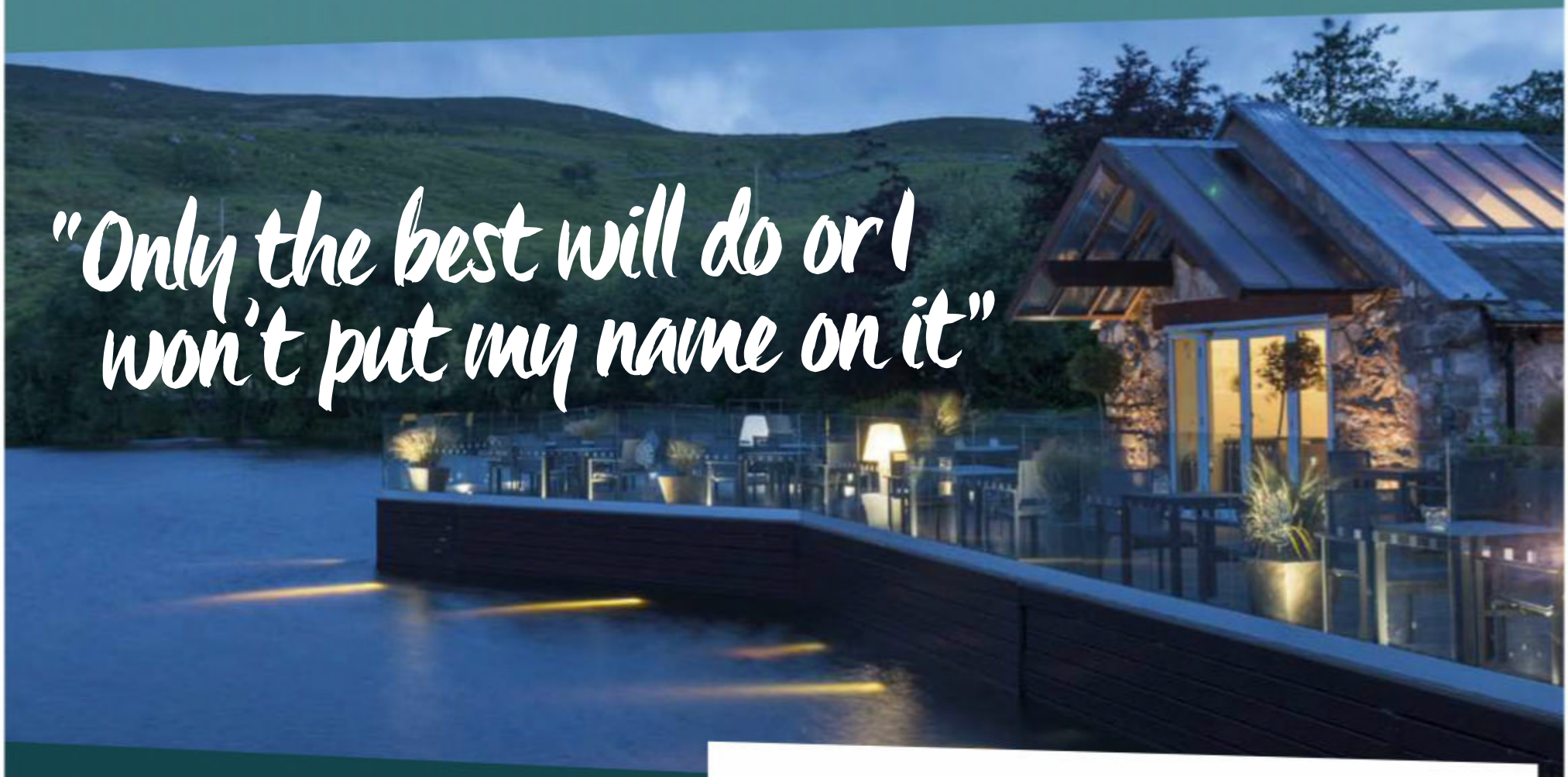
Cite examples of councils that have already addressed skyglow by installing night-sky-friendly streetlights. Dumfries and Galloway Council and Northumberland County Council have both undertaken a refit of all of their old, unshielded streetlights and replaced them with zero upward light LEDs.

It's no coincidence that these councils are near two of the UK's Dark Sky Parks, and while the initial impetus might have come from astronomers promoting off-season tourism, the reality of lower energy bills and carbon emissions made these refits even more appealing to council planners.

When struggling to find somewhere to stargaze that's free from glare or skyglow, it can often feel like we're fighting a losing battle against light pollution. But with public interest in astronomy skyrocketing thanks to recent eclipses and space missions, plus programmes like the BBC's *Stargazing Live*, and with councils looking for ways to spend their money more efficiently, the tide might be finally turning.

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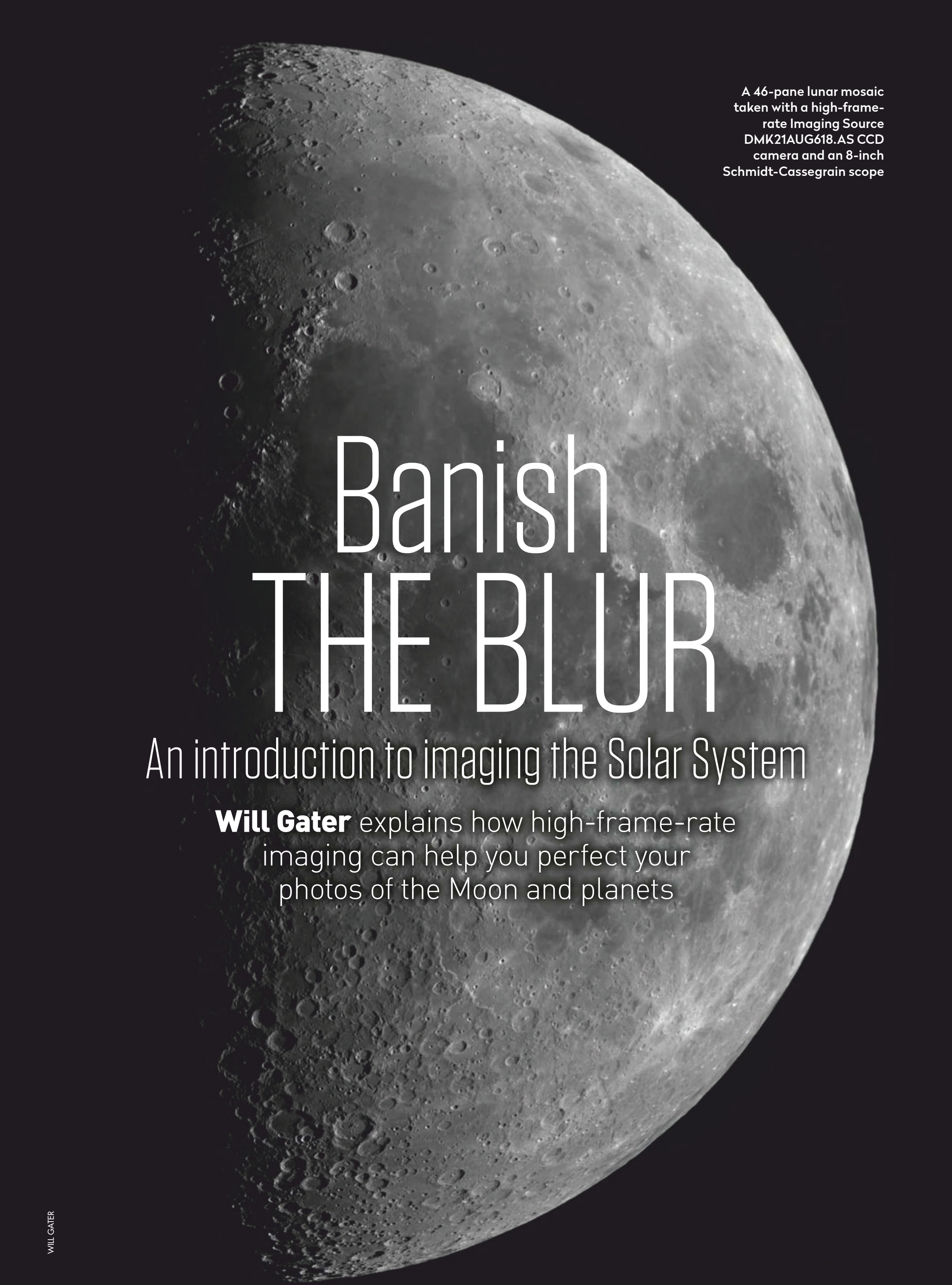
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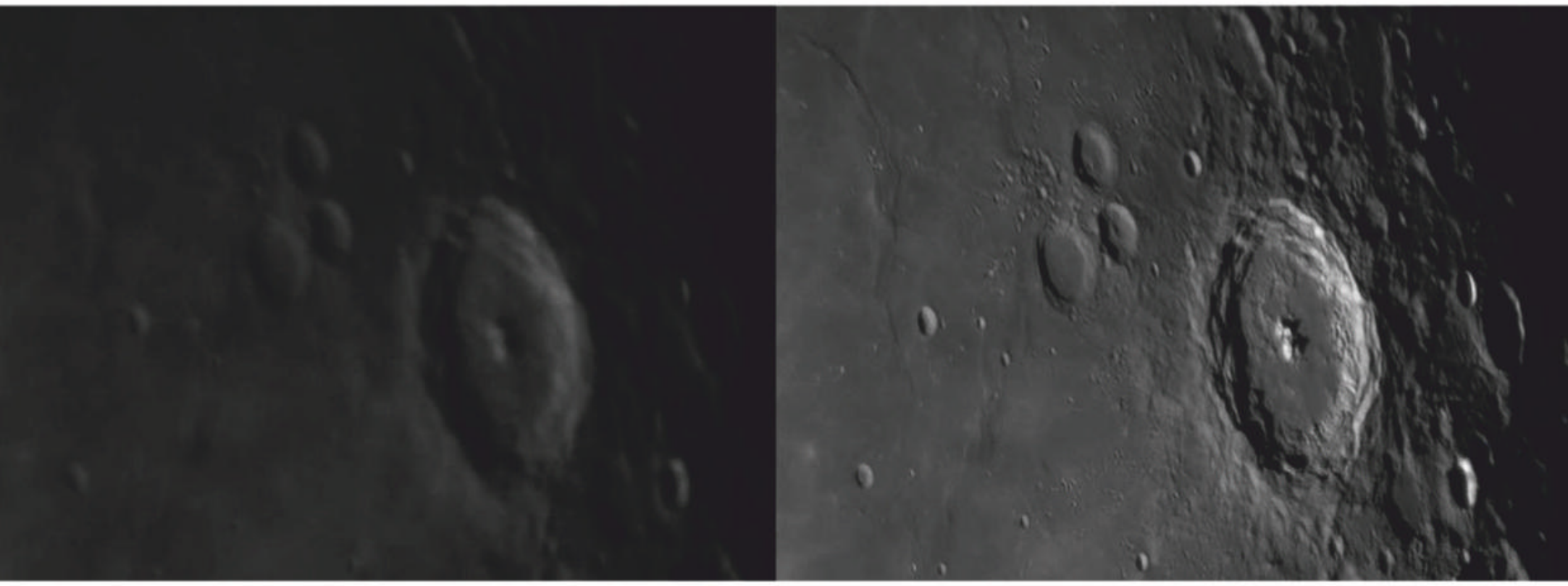
A 46-pane lunar mosaic taken with a high-frame-rate Imaging Source DMK21AUG618.AS CCD camera and an 8-inch Schmidt-Cassegrain scope

Banish THE BLUR

An introduction to imaging the Solar System

Will Gater explains how high-frame-rate imaging can help you perfect your photos of the Moon and planets

WILL GATER



▲ **A single frame from an AVI (Audio Video Interleave) file (left) and the processed final image comprised of hundreds of stacked frames from the same AVI (right)**

While observing the bright planets or surface of the Moon through a telescope, you'll have witnessed – without question – that rather than being perfectly still, the scene dances on the spot, with constant undulations that blur the view. And if you're lucky, you'll have caught those odd moments when the view seemingly snaps into focus for a split second, before continuing to jump to and fro.

What you're seeing are the distorting effects of the atmosphere. As the light from the Moon and planets, and indeed all celestial objects, passes through the air above us, it's refracted by myriad different regions of moving air, the combined effect being a jittering and blurring image at the eyepiece. Astronomers refer to the state of these distortions as the 'seeing' conditions.

A few decades ago, if you wanted to take a high-resolution lunar or planetary still image you'd have had to hope that these seeing conditions weren't too turbulent so the blurring would be minimal. That all started to change for us amateurs around the turn of the millennium, when back garden astrophotographers began adapting webcams for use with telescopes. These off-the-shelf cameras could take the place of an eyepiece, and be used with capture software to create detailed pictures of the planets and the lunar surface.

Instead of taking still images, the webcams recorded short videos which could then be analysed by free astronomical software that sorted through the hundreds, if not thousands, of individual frames captured in the video. The frames with the sharpest views taken during those rare moments of good seeing could then be combined into one high-quality still image, which could be sharpened and processed even further.

Professional astronomers sometimes refer to this technique as 'lucky imaging', though in amateur circles it's more commonly known today as high-frame-rate (HFR) imaging. And though cameras today are much more advanced, the basic principles and methods haven't changed.

The kit you'll need

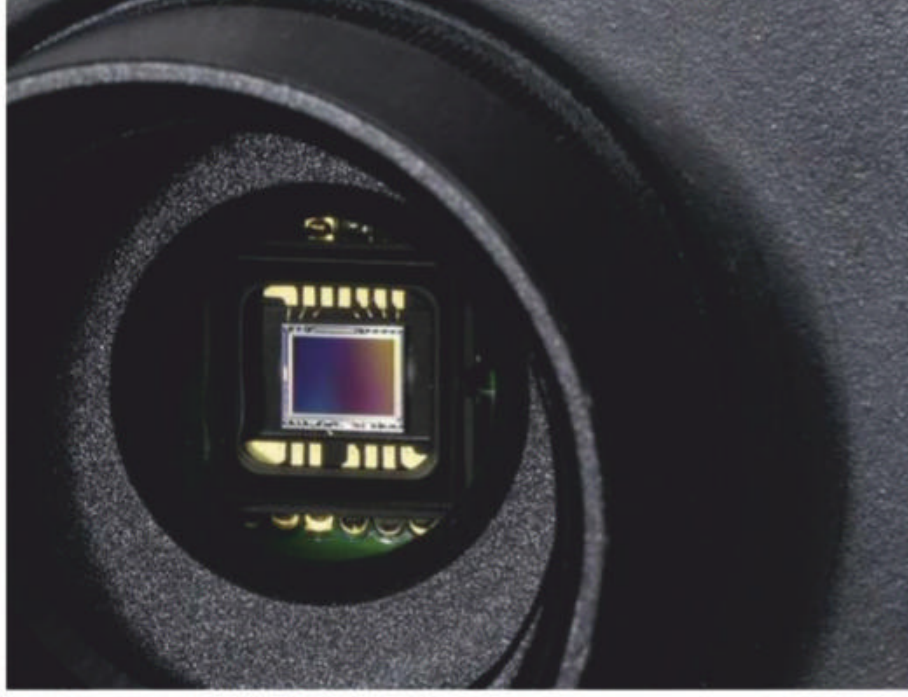
Any good-quality telescope can be used for this type of work, but because of their inherently long focal lengths and favourable aperture-to-price ratio, most lunar and planetary imagers tend to gravitate towards using larger Schmidt-Cassegrain or Newtonian-style telescopes. A larger aperture instrument has the ability to resolve more detail and collect more light, which reduces the need to electronically amplify the image brightness, potentially introducing degrading noise (unwanted image artefacts) into the final shot.

While the high magnifications and small fields of view of these telescopes are less suited to wide-field, deep-sky imaging, it's ideal for HFR imaging. That's largely because, even at their greatest angular diameter, the planets and lunar features appear very small on the sky; so a telescope that gives a narrow, close-up field of view and a

▼ **A Schmidt-Cassegrain telescope paired with a high-frame-rate (HFR) camera can produce exceptionally sharp images**



WILL GATER X 7, STEVE MARSH, PAUL WHITFIELD

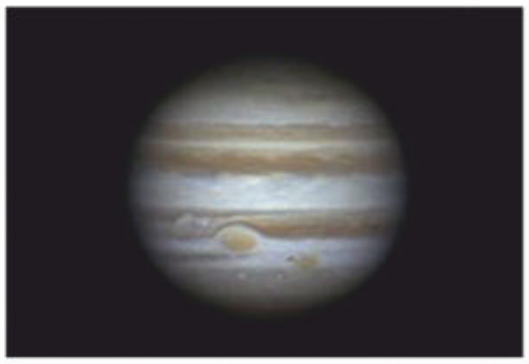


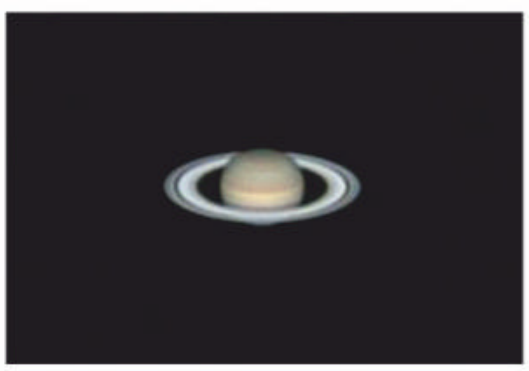
► **Although most HFR cameras have very small sensor chips, these work well alongside telescopes with a narrow field of view**

camera with a relatively small sensor chip (as most basic high-frame-rate cameras have) are a good match.

In fact, many of us lunar and planetary imagers have spent years happily using high-frame-rate cameras that have sensors measuring only 640 by 480 pixels. This is perfectly sufficient for most planetary imaging and if you wanted to capture a wider area of the lunar surface, for example, you'd simply create a mosaic by overlapping frames and stitching them together in image-editing software.

High-frame-rate camera technology has advanced tremendously, so there are now models available with not only lower inherent noise in their images but with much larger sensors too, increasing the area of the lunar surface captured in one video. With cameras like this you don't have to image a planet without unnecessarily capturing masses of empty black space: you can simply programme the camera to only record a small region within the larger field of view, at rates of perhaps several hundred frames per second.





◄ **The author's images of Jupiter and Saturn were captured with a CCD camera paired with RGB (red, green and blue) filters and an 8-inch Schmidt-Cassegrain telescope**

The impressive frame rates attainable by modern high-frame-rate cameras are great for capturing those all-important instances of good seeing, but they do highlight another equipment requirement of this technique: a computer with enough computing power and input ports to receive and record the large flow of data from the camera. Your camera manufacturer or retailer will be best able to advise on the requirements for your particular model.

If you're just starting out in high-frame-rate lunar and planetary imaging you'll also want to invest in some way of storing all the data produced by your camera. It's not unusual to capture tens, if not hundreds, of gigabytes of data in a single imaging session, so we personally favour a ►

A typical high-frame-rate imaging setup

Four essential pieces of equipment that you'll need for obtaining sharp views of the Moon and planets



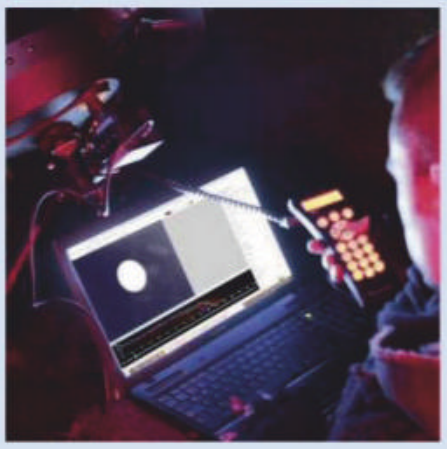
Imaging telescope

Most high-resolution, high-frame-rate (HFR) imaging of the Moon and planets is done using Schmidt-Cassegrain (as shown above) or Newtonian telescopes. Alternatively, excellent high-resolution images can also be obtained with large refractors.



High-frame-rate camera

The cameras used for HFR lunar and planetary imaging tend to be smaller than DSLRs and other astronomical CCDs. They take the place of the telescope's eyepiece and connect via a short, 1.25-inch diameter nosepiece that fits into the eyepiece adaptor or filter wheel.



Computer running capture software

Some imagers use a laptop to run their software 'in the field' and move to a desktop for image processing. If you're running a laptop outside, be sure to protect it from the elements and use a certified RCD circuit-breaker device along with the power supply.



Portable external hard drive

An external hard drive is a handy and efficient way to store and archive the large volumes of data that are created by your high-frame-rate imaging sessions. A 2TB external hard drive can be purchased online for around £60–70.

▸ portable external hard drive to store the data from our capture software. If your camera doesn't come with its own, there are capture programs available online to choose from.

Getting started

The first task when imaging the Moon and planets is to set up your telescope on its mount, and get the latter tracking as accurately as possible. This may mean, for example, that when imaging the Moon you set the mount's tracking rate to the lunar rate and not the sidereal rate – the rate at which the stars move across the sky. You'll also want to check that your telescope is well collimated, as poorly aligned optics can seriously reduce the amount of fine detail in your final images. If you have a Barlow lens, or Powermate, and want to increase the magnification of your setup to get a bigger image of a planetary disc or lunar feature now's the time to securely attach it to the camera, before putting them both in the eyepiece holder.

Once you've got the scope tracking the object you're intending to image and the high-frame-rate camera in place, the next big job is to focus the view and set the exposure.

To achieve a satisfactory image brightness, aim to increase the exposure length of the camera first before resorting to tweaking the 'gain' setting – how electronically amplified the image brightness is – as increasing the latter can introduce unwanted noise. Be careful, though, not to use such a long exposure length that the camera can't actually shoot

WILL GATER X 4, WWW.FIRECAPTURE.DE, PETE LAWRENCE

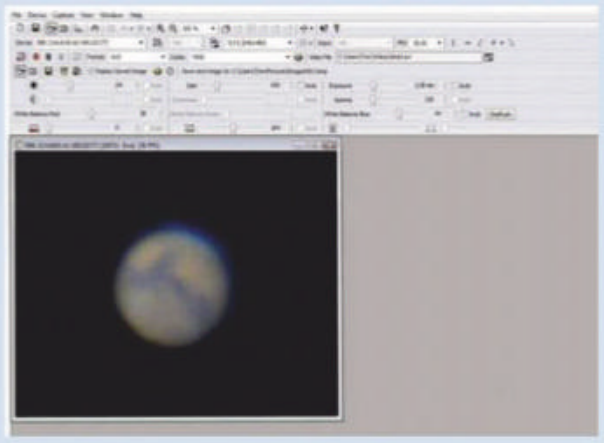


Will Gater is an astronomy writer and presenter. Follow him on Twitter at @willgater or visit willgater.com

Software links

For HFR imaging you'll need capture software, a program to stack and sharpen images and one to add finishing touches

Capture software

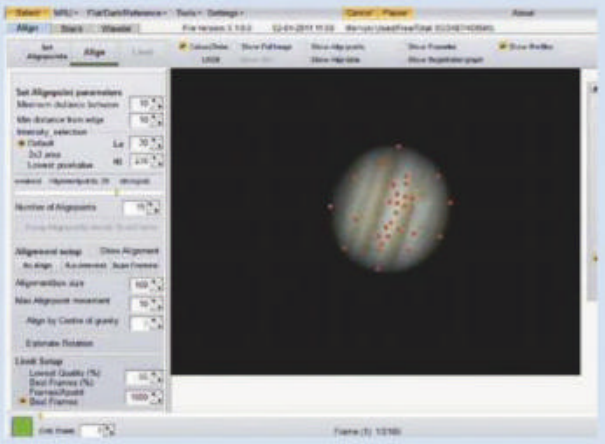


SharpCap
www.sharpcap.co.uk

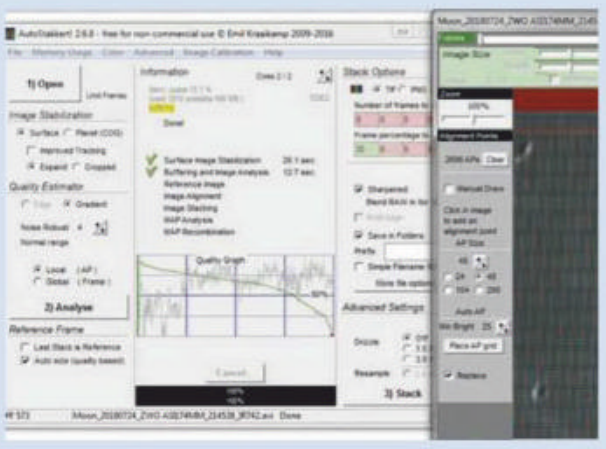


FireCapture
www.firecapture.de

Video analysis and stacking

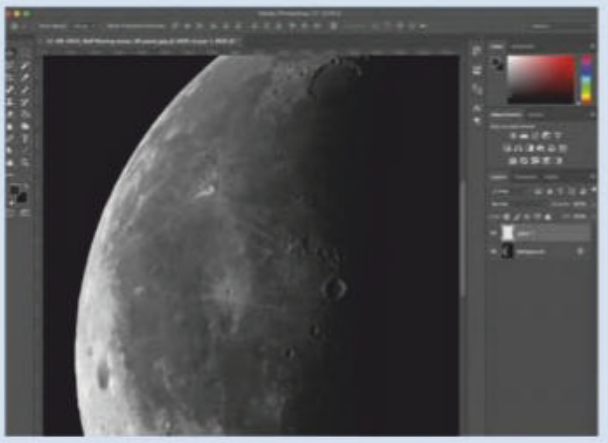


RegiStax
www.astronomie.be/registax



AutoStakkert!
www.autostakkert.com

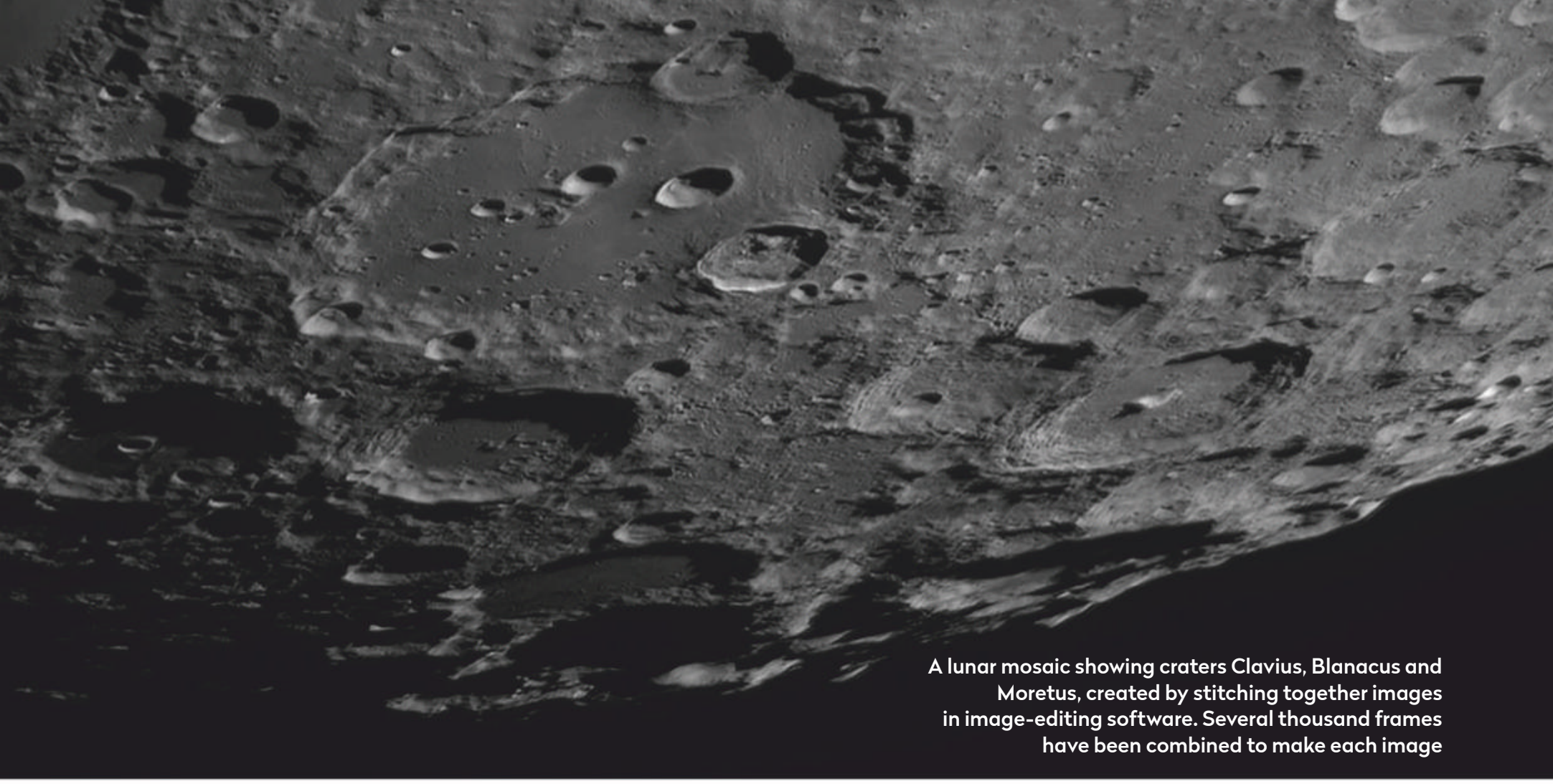
Image editing software



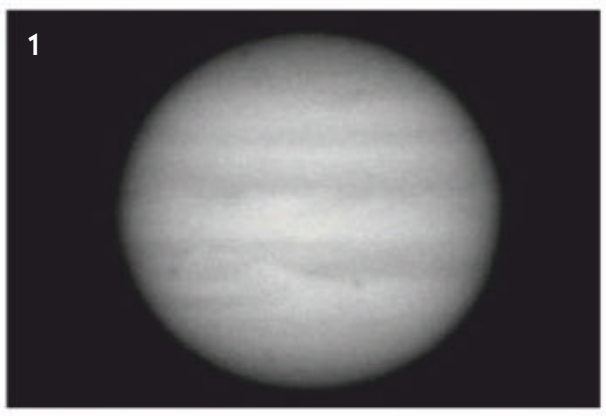
Photoshop
www.adobe.com/photoshop

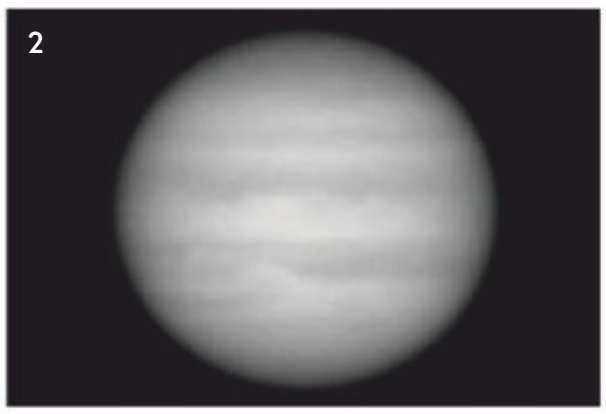


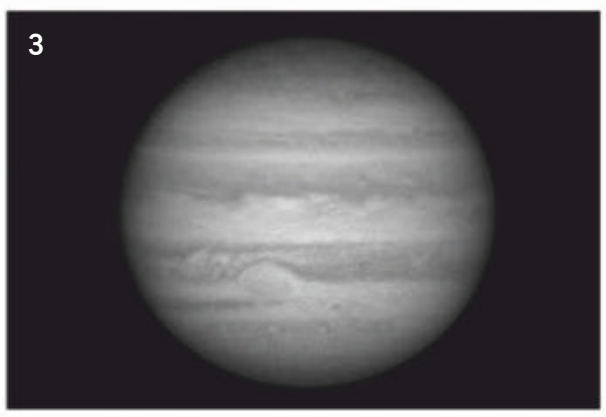
GIMP
www.gimp.org



A lunar mosaic showing craters Clavius, Blanacus and Moretus, created by stitching together images in image-editing software. Several thousand frames have been combined to make each image







▲ The power of stacking: 1. a single AVI frame of Jupiter 2. 500 AVI frames, aligned and stacked 3. a 500-frame image wavelet sharpened in RegiStax

at high frame rates. For example, if you're shooting at 1/60th of a second you won't be able to achieve a frame rate that is better than around 60fps.

When focusing on the Moon's surface, it's useful to first find a high-contrast area, like the terminator, or a partially shadowed crater to focus on before moving to your intended target. For Jupiter, the Galilean moons make very handy focusing aides as you can try to make them as small as possible. Whatever you're imaging, spend a good amount of time tweaking the focus back and forth, waiting for moments of better seeing to establish how well you're doing. Now you can start capturing your short videos. These are recorded in the AVI (Audio Video Interleaved) format and are what you'll feed into image processing software later.

Most good capture software will tell you how many frames have been recorded during the capture process; so aim to gather a few thousand frames per video. Be sure not to go over about a minute in length for high-resolution imaging of Jupiter as its fast rotation will start to blur the cloud features in your final shot.

For one shot colour cameras and monochrome imaging of the Moon, you've now got all you need for the final image. But if your camera has a mono sensor and you're imaging the planets, you'll need to capture three consecutive videos – through red, green and blue filters – if you want to produce a full-colour image.

Processing your results

Processing begins by opening the AVI video file in software such as RegiStax or AutoStakkert!. The next steps vary from program to program, but essentially the software is used to analyse the quality of the frames in the video and align them with one another. You can then select how many of the best-quality frames you want to stack and the program will combine them together into a kind of 'super' image.

RegiStax has a wavelet tool that can really help a lunar or planetary shot come to life. This is essentially an advanced sharpening filter that can bring out subtle details hidden in the 'raw' image made from the aligned and stacked video frames. On the tool you'll see six sliders that can be used to increase the sharpening applied to the image, with the upper ones working more on fine details in the picture. To enhance your image, move the sliders to the right carefully in small steps. Make sure not to create an over-processed look where the shadows look noisy and there are hard, high-contrast edges to fine details – like cloud-band features, the periphery of Saturn's rings and lunar crater rims.

Once you're happy with the shot, you can save it as a PNG or TIFF and then make any final enhancements in image editing software like Photoshop or GIMP. You'd also use programs like this to combine the three individual colour filter images if you were imaging the planets with a monochrome-sensor camera.

As you get more experienced with high-frame-rate imaging of the Moon and planets, you'll come to appreciate one of the most enjoyable aspects of this field of astrophotography: that no night is ever really the same, with new challenges and targets. And with the dynamic atmospheres of Mars, Jupiter and Saturn and a waxing and waning lunar disc among the potential targets, you'll rarely find yourself stumped for something to point your scope at. The only thing that can't be guaranteed are decent seeing conditions.

Practical astronomy projects for every level of expertise

DIY ASTRONOMY

Protect your eyepieces

Clean and organise your oculars to keep them in tip-top condition

All your optical equipment deserves to be maintained and handled carefully so that it performs at its best, but your poor eyepieces take the brunt of abuse, exposed to a natural source of unwanted contaminants and risk – you!

Just handling them deposits fingerprints and grease on the body of the eyepiece and it is all too easy to accidently leave a fingerprint on the optics themselves. Simply placing your eye in position will transfer tiny amounts of grease onto the lens, as well as fragments of eye lashes, dry skin and traces of cosmetics. Dust, pollen and other contaminants will also collect on the optical surfaces. All of this is bad news for the anti-reflection coatings on the lens surface and ultimately the quality of the view.

Safe storage

Eyepieces are constantly being swapped in and out, and this is fraught with danger too. It really pays to have them in a container within easy reach of your telescope and kept in a logical order. Not only does this make using them easier but it ensures that they don't roll off on to the ground with potentially disastrous consequences.

The best solution when you're outdoors is a foam compartmented box. A plastic ice cream container or food storage box with foam cut-outs for the eyepiece barrels, and an easy to lift off temporary cover, is ideal. For permanent indoor storage, consider a low-cost aluminium flight-case-type container, with pluck foam interiors to ensure that the eyepieces cannot rub against one another.

Your eyepiece dust caps are a first line of defence, so these should be regularly cleaned using a small brush followed by blasts from a high-power bulb air blower. The body of the eyepiece can be gently wiped with a lint-free cleaning cloth to keep it dust and grease-free. Stubborn marks on the metal body can be cleaned by spraying a multi-surface cleaner onto a cloth and buffing the surface clean (never spray directly onto the eyepiece itself). The rubberised grip can be cleaned by wiping it with a moist sponge. The lenses, however, will require very careful attention to ensure that you don't turn a dirty lens into a damaged one.

During an observing session your eyepieces will almost certainly cool down significantly, so allow for this when you bring them back inside. Leave them in your observing container with the lid removed or lie them safely on their side on a towel while they return to room temperature. The last thing you want to do is pack them away damp. Once the eyepieces are dry and up to room temperature you should install the dust caps and return them to their permanent storage.

Look after your eyepieces and they will reward you with many years of good service.





▲ **Before and after: regular cleaning will keep dust, fingerprints and debris at bay**

ALL PICTURES: STEVE RICHARDS

Tools and materials

- A high-power bulb air blower (with the brush attachment removed) to shift loose dust particles without touching the lens surface.
- A bottle of Isopropyl alcohol or lens cleaning fluid to remove grease marks and dissolve stuck-on debris.
- Lint-free lens cleaning tissues to apply the fluid while carefully cleaning the lens surface.
- A micro-fibre cloth to remove any smearing left by the tissue and fluid and to give the lens surface a final polish.
- A reading light or torch to allow a close examination of the lens surface.



Steve Richards is an astro imager and author of *Making Every Photon Count: A Beginner's Guide to Deep Sky Astrophotography*

Step by step



Step 1

Keep your eyepieces safe, dry and free from dust in a suitable closed storage box with the eye caps attached. The eyepieces should be separated from one another by foam padding to avoid any physical damage.



Step 2

Eyepieces are, of course, at their most vulnerable when outside in the dark, so transfer them to a suitable open storage box that will keep them from rolling about. Arrange them in focal length order and protect them with a lift-off lid.



Step 3

Use a high-power blower bulb held near to, and directed at, the front of the lens. Direct several sharp blasts of air at the surface to dislodge loose dust particles. Hold the eyepiece with the eye lens pointing downwards and the barrel capped.



Step 4

Grease, fingerprints and stubborn particles need to be dissolved away with cleaning fluid. Apply two drops of the fluid to a fresh lens cleaning tissue and carefully wipe from the lens centre outwards. Never apply fluid directly to the lens.



Step 5

While the lens is still moist with the fluid, use a micro-fibre cloth to very gently polish the surface to remove any smears left by the previous cleaning process. Only press very gently, using a fresh area of the cloth, turning it as you work.



Step 6

Carefully examine the lens under a bright light or torch to check for any stubborn particles or greasy marks. Repeat from Step 4 using fresh tissues each time until you are happy that you have got the surface as clean as possible.

What KEPLER did for us

NASA's first exoplanet hunter, the Kepler space telescope, has retired. **Paul Cockburn** reveals how it has changed our view of the Universe

The Kepler space telescope didn't discover the first planet orbiting a star beyond our Solar System – an exoplanet – but it was still a transformative scientific mission, says *The Sky at Night* co-host Chris Lintott.

"I start public talks these days by talking about the fact that we now know, when you look at the night sky, that most of those stars have planets. That's a discovery that's due to Kepler," he says. "I think that fundamentally changes our view of the Universe, which is an amazing thing for a science mission to have done. It certainly changes the way I look at the night sky."

NASA decided to retire Kepler in October 2018 when it ran out of fuel. But unlike many missions, such as the Cassini probe at Saturn or the MESSENGER spacecraft at Mercury, its current 'safe' position means that there will be no need for a controlled crash: Kepler will continue to orbit the Sun just behind Earth, falling further behind over time.

Kepler was arguably the baby of William J Borucki of NASA's Ames Research Center. As early as 1983 he began researching the potential of photometers – high-precision light detectors – to detect Earth-sized exoplanets from the distinctive dip in starlight they cause while crossing in front of their stars.

It would be the best part of a decade, in 1992, before this technique – known as 'transit photometry' – produced the first confirmed exoplanets, unexpectedly orbiting a pulsar. That same year, Borucki and his team submitted their first proposal to NASA's Discovery Program: a three-year mission using transit photometry to test their hypothesis that most stars have planets orbiting around them. The proposal was rejected.

What would eventually become the Kepler mission – named after the 17th-century German astronomer Johannes Kepler, who discovered the laws of planetary motion – would be rejected on four separate occasions before it was finally approved in 2001, becoming NASA's 10th 'Discovery-class' mission. Borucki would remain Kepler's principal investigator until his retirement in 2015.

A new era of discovery

Launched on 6 March 2009, NASA's first planet-hunting space observatory was placed into an 'Earth-trailing' orbit around the Sun, ready to focus its attention on a small patch of sky in the northern constellations of Cygnus, Lyra and Draco. ▸



Paul F Cockburn is a science and astronomy journalist

NASA/JPL-CALTECH/R. HURT, NASA AMES/JPL-CALTECH/T PYLE

On its near decade-long mission, plucky planet-hunter Kepler discovered more than 2,600 worlds beyond our Solar System

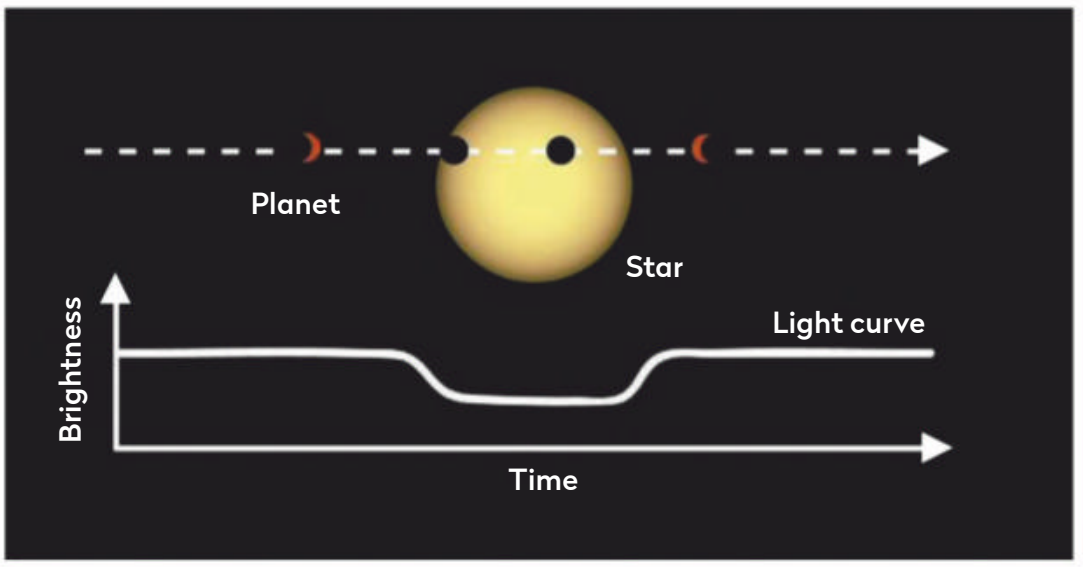
▸ Although covering just 0.25 per cent of the sky, Kepler was nevertheless expected to commence the regular observation of more than 150,000 main sequence stars (in the end, it would observe 530,506), using what was at the time the largest camera system launched into space, with a total resolution of 94.6 megapixels. During its operational lifetime of more than nine and a half years, Kepler would collect some 678GB of science data.

Kepler's legacy consists of more than just its 2,662 confirmed exoplanet discoveries. We can now confidently claim that planets outnumber stars in the Galaxy. Kepler also showed us that, while we may talk of 'hot Jupiters' and other bizarre worlds, anywhere between one fifth and a quarter of stars are statistically likely to be orbited by worlds similar to Kepler-22b, discovered in 2011: that is, between the size of Earth and Neptune, rocky, and orbiting within their stars' habitable zones.

Above all, Kepler has shown just how varied exoplanets and other planetary systems actually are: potentially ranging from single gas giants orbiting close to their stars (or, in the case of Kepler-16b, whose discovery was announced in September 2011, orbiting around twin stars), to the likes of star Kepler-90, which is now known to have eight worlds all crowded around it closer than Earth is to the Sun.

As a result, Kepler has inevitably transformed our understanding of how our own Solar System formed, forcing us to rethink almost everything we had previously assumed, and raising new questions, such as: why is the most common size of exoplanet found by Kepler – between the size of Earth and Neptune – missing from our own Solar System?

Unlike the Hubble Space Telescope, which NASA astronauts were uniquely able to visit after its launch to make repairs, Kepler's location meant that when a



▲ Kepler found planets by transit photometry – looking for tiny dips in the brightness of a star when a planet crossed in front of it

NASA AMES, CHRIS MEANEY/NASA GODDARD, NORTHROP GRUMMAN, ESA/C. CARR
ALENIA SPACE, NASA/JPL-CALTECH X 2, NASA/AMES RESEARCH CENTER/WENDY STEN

Beyond Kepler

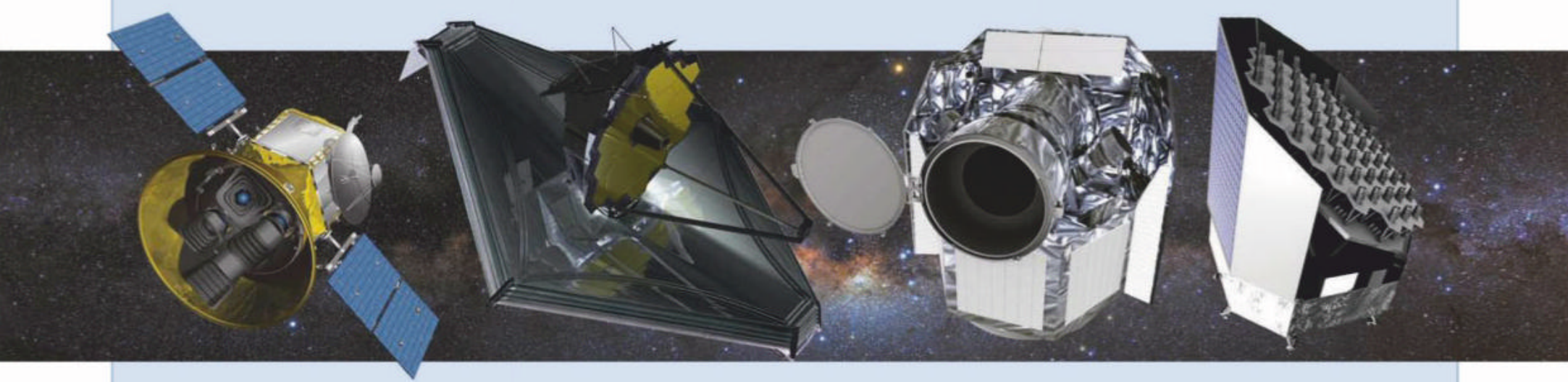
The end of Kepler signals the beginning of a new era in planet hunting

"New missions will build on Kepler's discoveries, including the Transiting Exoplanet Survey Satellite (TESS) and the James Webb Space Telescope," says Dr Paul Hertz, NASA's astrophysics division director.

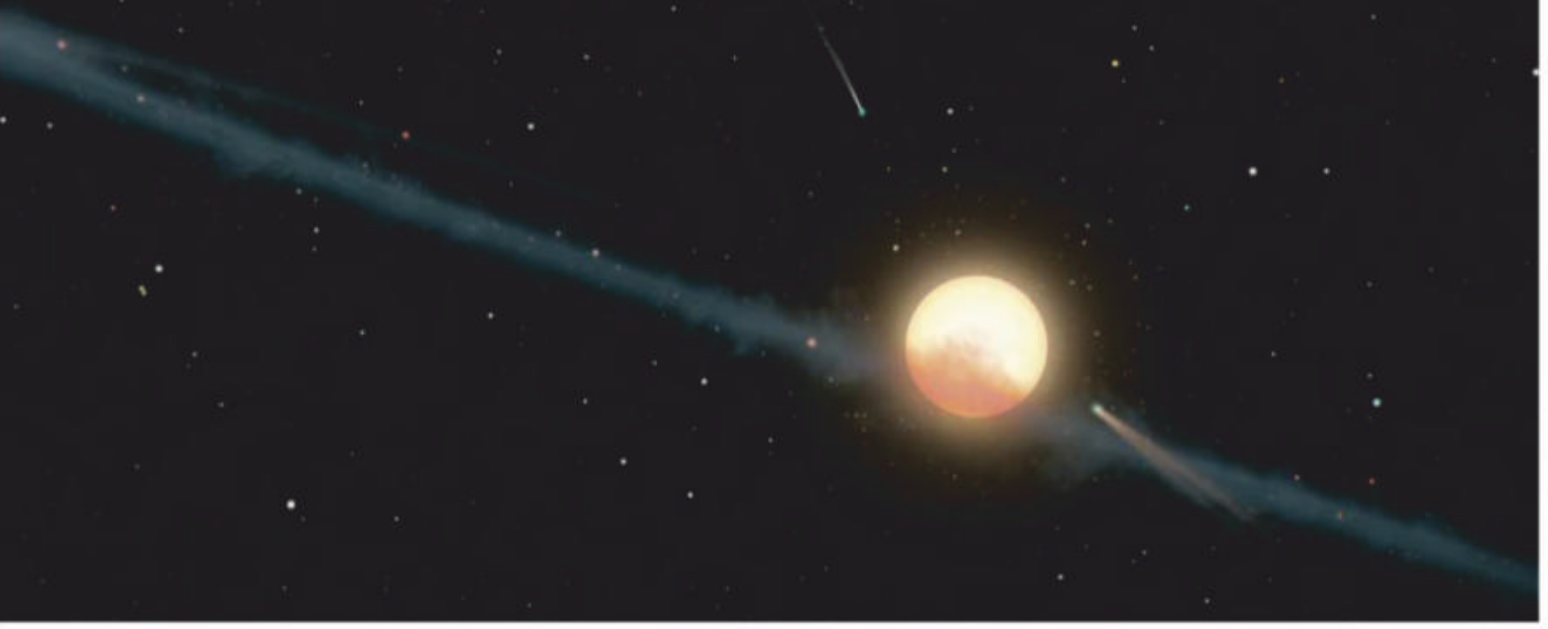
The former is already in position; unlike Kepler, which observed 1/400th of the sky over a period of four years, TESS will study nearly the entire sky, monitoring different sections for 27 days at a time, with smaller fractions of the sky being observed for up to a year. Expectations are that TESS will catalogue more than 1,500 transiting exoplanet candidates, including rocky worlds in the habitable zones of their host stars.

CHEOPS (CHaracterising ExOPlanet Satellite), a joint project between the European Space Agency and the Swiss Space Office, is expected to launch later this year. Essentially a follow-up to Kepler, CHEOPS will provide far more accurate measurements of known Earth-to-Neptune-sized exoplanets. ESA's PLATO (PLAnetary Transits and Oscillations of stars) will follow in 2026, again with an emphasis on detecting potentially habitable worlds.

Unlike these missions, the long-awaited NASA/ESA James Webb Space Telescope – now set to launch in 2021 – will observe the Universe in the infrared. The advantage of this is that it will provide clearer spectroscopic information on the make-up of the exoplanets' atmospheres.



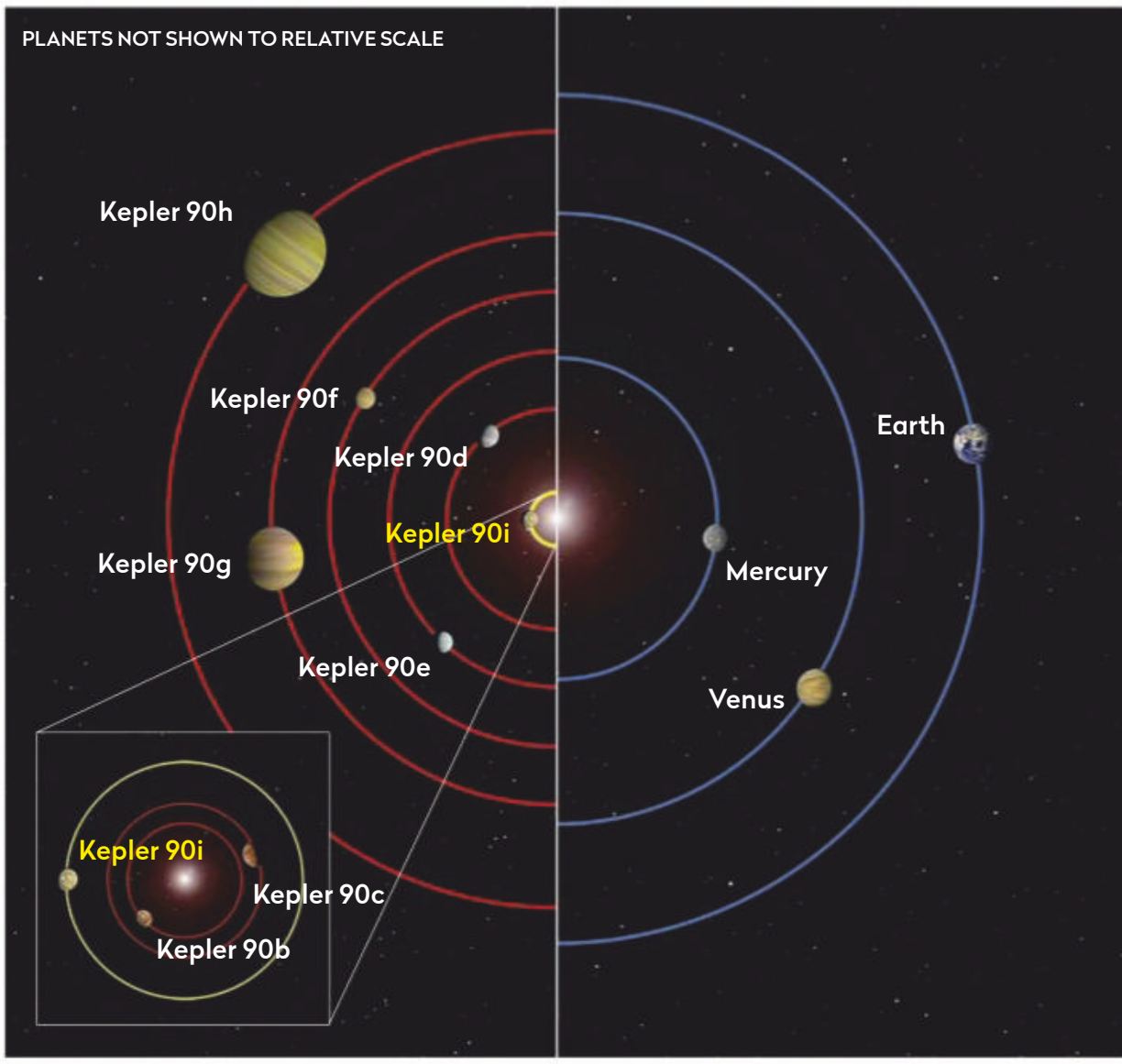
▲ TESS, the James Webb Space Telescope, CHEOPS and PLATO all continue Kepler's legacy of alien world exploration



◄ Mysterious Tabby's Star, found to be dimming erratically, sparked a frenzy of speculation



▲ Even planets orbiting two stars were found; imagined here is a watery planet near host suns Kepler-35A and B



► Another first: Kepler-90 and its eight exoplanets in Draco, inhabiting an area the size of Earth's orbit

second of the four reaction wheels used to fine-tune the telescope's position failed, its original mission was effectively over.

Kepler's second life

However, thanks to some ingenious thinking on the part of NASA scientists and technicians, Kepler lived on with a second mission, K2, making use of the telescope's remaining capabilities and taking advantage of the pressure of sunlight to help stabilise the telescope.

This also meant that Kepler was required to switch its field of view every three months or so, bringing many new patches of sky under its gaze. In October 2015, the K2 mission found evidence of a small, rocky planet being torn apart as it orbited a dense, white dwarf star. This enabled astronomers to witness the final stages of a planetary system in the strangely-shaped transit data.

In January 2018, an Australian car mechanic sifting through K2's data discovered a four-planet system with Neptune-size worlds. "Kepler has demonstrated, almost definitively, how important sharing data openly is in astronomy," insists Chris Lintott.

"People worldwide have made enormously good use of the Kepler data and, as the mission went on, it became much more open. You could see the effect of that; more people – more junior people – are getting to publish discoveries from the data.

"Also, one of the nice side things that came out of Kepler and citizen science was what came to be known as 'Tabby's Star'," he adds. "This very unusual star was discovered by planet-hunter volunteers who did that very human thing of noticing something odd and setting off on this wonderful, joyful wild goose chase to try to work out what on earth was going on."

NASA estimates that some 2,946 scientific papers have so far been published using Kepler data. "We know the spacecraft's retirement isn't the end of Kepler's discoveries," says Jessie Dotson, Kepler's project scientist at NASA's Ames Research Center. "I'm excited about the diverse discoveries that are yet to come."

BBC RADIO 4

Listen to *Material World* in which Quentin Cooper speaks to William J Borucki, the Kepler mission's principal investigator. **www.bbc.co.uk/programmes/b01ppn8l**

Help discover exoplanets

If you would like to get involved in analysing Kepler data, visit **www.nasa.gov/kepler/education/citizen** *to get started.*

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE



A simulated, combined sequence shot of the red planet passing the icy-blue cluster

Mars passing the Pleiades

Catch the drama as the Red Planet meets the sparkling star cluster in Taurus

Mars will be passing the beautiful Pleiades open cluster between 1 and 10 April. Despite now appearing relatively dim, the planet's reddish hue will still be revealed by a camera as it moves past the distinctly blue-white of the stars. Deeper shots may also reveal the blue reflection nebula that permeates the cluster. Bringing these colours out to their best effect will create a stunning image.

The encounter will take place in the western sky under dark conditions – an irresistible combination for astrophotography. As it remains reasonably well posed for several days, there's a good chance of beating the weather too. If you hit the jackpot and the sky remains clear for several evenings, you could also combine your shots to create a sequence showing just how quickly the planet moves relative to the background stars.

ALL PICTURES: PETE LAWRENCE



Pete Lawrence is an expert astro imager and a presenter on *The Sky at Night*

To reveal the nebula, a multi-second exposure is required. The cleanest and deepest tones will be achieved using relatively low ISO values, but this will necessitate a longer exposure to record enough signal to reveal the nebula at its best. A tracking mount will therefore be required.

Another consideration is field of view. Mars will be 3.3° from the cluster on 1 April. This distance increases to 7.6° on 10 April and by 30 April it will have increased to 20.2°. The size of lens you'll need depends on how long you intend to cover both objects for and the size of your camera's sensor. To record just the closest approach on 1 April with an APSC-sensor camera requires a 300mm or shorter focal length lens. For a full-frame camera you need a 400mm or shorter lens. To record the entire 1–10 April passage you need a 100mm or shorter lens on an APSC-sensor camera or a 160mm or shorter lens on a full-frame camera. If your ambition is to cover the whole month, you will need a 50mm or shorter lens for an APSC sensor or an 80mm or shorter lens for a full-frame sensor.

As well as the attraction of catching Mars close to the Pleiades, there are other opportunities available during April too. A shorter focal length lens can be used to increase the field of view to allow the Hyades open cluster to be captured at the same time as Mars and the Pleiades. Although they are more dispersed than the Pleiades, the V-shaped Hyades cluster still makes a superb target for wider lenses. The orange colour of the bright star Aldebaran (Alpha (α) Tauri) will also make a great comparison target when captured in the same image as salmon-pink Mars.

Then there's the Moon, of course. On the evenings of 8 and 9 April its bright waxing crescent will gatecrash the party, creating a whole new set of things to consider. With care, this beautiful alignment of Solar System and deep space has the potential to deliver a really stunning result.

Recommended equipment: DSLR or mirrorless camera, mid to wide lens, tripod or tracking mount, remote shutter release

✉ Send your images to:
gallery@skyatnightmagazine.com



STEP 1

The first decision is to determine what lens to use. We've mentioned a number of focal lengths, but it's also worth considering giving the image a bit of space to breathe. If your shot has the Pleiades tight in one corner and Mars tight in the other, it will feel constrained by the frame edges.



STEP 2

It's possible to record Mars and the Pleiades from a fixed tripod: open the lens to the lowest f-number, select a relatively high ISO and keep the exposure short. To determine an exposure length to minimise star-trailing, follow the 500 rule: divide 500 by the lens's focal length to get your maximum exposure value.



STEP 3

As ever, focus is crucial but the stars of the Pleiades make great focus targets. If your camera supports it, use the maximum live view magnification possible; wind the focus ring back and forth through the focus point. Once you've done this you'll know what correct focus looks like and be able to snap to it accurately.



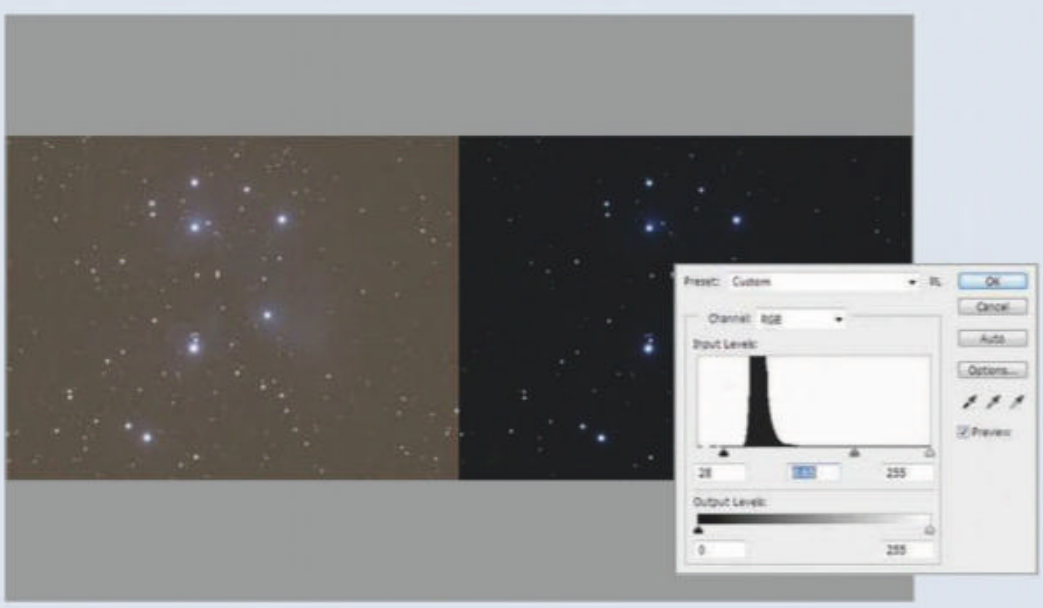
STEP 4

If you use a fixed tripod, try lowering the ISO and/or increasing the lens f-number while taking, say, a five-minute exposure so the stars deliberately trail – a great way to reveal colour that may otherwise appear burned out. The normal way to do this is to set the exposure to 'bulb' and use a remote shutter release.



STEP 5

A tracking mount is required for longer or lower ISO shots. One way to do this is to piggyback the camera on a polar-aligned telescope setup. Here you can drop the ISO to reduce noise and improve tonal quality. Make sure not to overexpose if you have light-polluted skies; reduce exposure time if necessary.



STEP 6

To darken bright skies, use the levels tool in your photo editing software. Darken the red channel mid-point slider until the image looks slightly green. Repeat with the green channel to create a slightly blue image, then correct the blue. Adjusting brightness and contrast can also help bring the image to life.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

Polish out imperfections with PixInsight

Using calibration to remove bias, thermal noise, dust shadows and pixel problems

PixInsight is a very powerful image-processing package, but it comes with a rather steep learning curve. Here we'll show you how to use the program to prepare your captured image files by calibrating them, ready for processing into a final image. For simplicity, we'll refer to your image files as 'lights'.

Image calibration is all about removing the unwanted artefacts that are produced during the image capture and download process. These artefacts include bias, thermal noise, hot pixels, dust mote shadows, inconsistent pixel to pixel sensitivity and light intensity fall-off. Other unwanted artefacts like gamma ray hits and satellite trails can be dealt with by using other techniques.



Steve Richards is an astro imager and author of *Making Every Photon Count: A Beginner's Guide to Deep Sky Astrophotography*



Detail from a single uncalibrated subframe of the Wizard Nebula in Cepheus

ALL PICTURES: STEVE RICHARDS

Bias, dark and flat frames

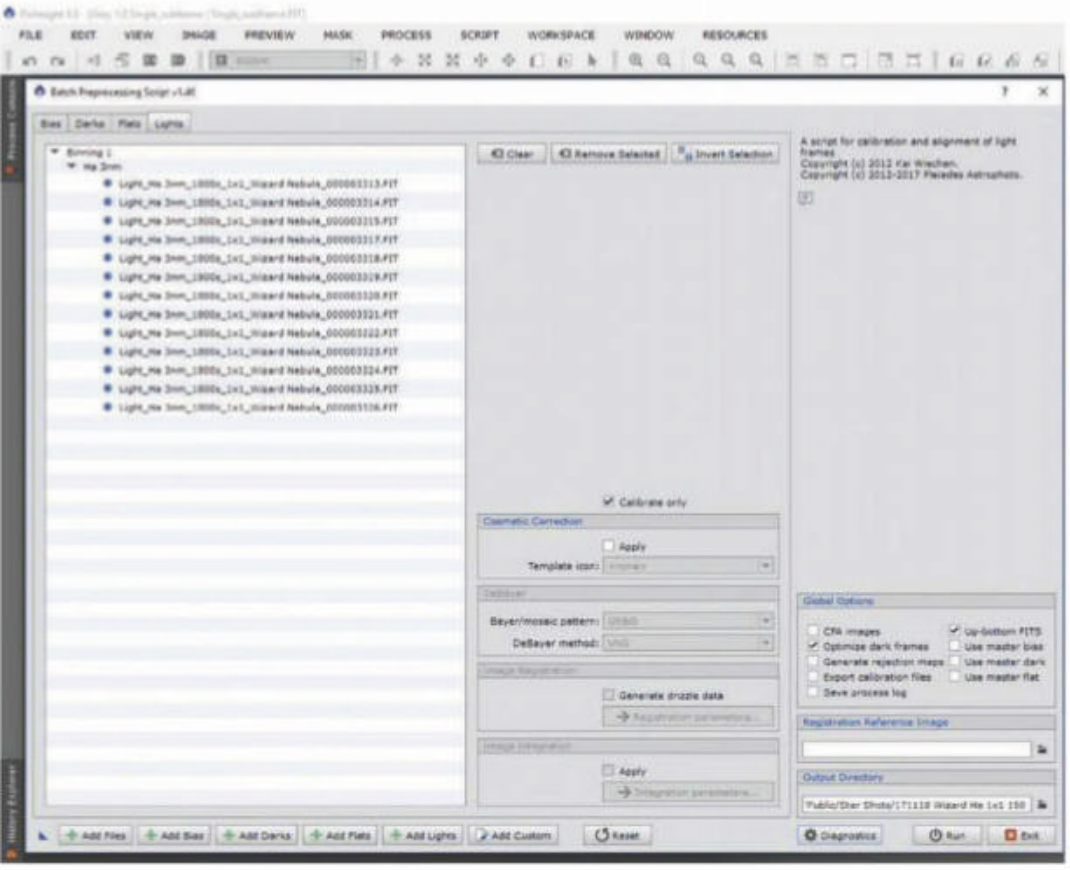
Bias is an unwanted signal produced when image data is read from the camera, and it varies across the area of the sensor. This signal is removed by subtracting a master bias calibration frame made up of 20 or more extremely short exposures captured with the telescope capped. As bias frames are quick and easy to capture, it is worth capturing as many as 50 because, when these are averaged out during integration, fixed pattern noise can also be removed using a greater number of bias frames.

Thermal noise – generated by the sensor as it heats up during long exposures – tricks the sensor into believing that it has received some photons, resulting in white pixels being peppered across the image. This fault can be offset by subtracting a master dark calibration frame. This dark frame is made up of 20 or more exposures of the same length and at the same temperature as your lights, and is again captured with the telescope capped. The master dark calibration frames must themselves be calibrated to remove their bias.

Inconsistent pixel sensitivity is a manufacturing by-product and light fall-off is a natural optical effect that can be exacerbated by obstructions in the telescope leading to vignetting, which makes the edges of an image darker than the centre. These faults and the shadows cast by dust motes can be largely removed by the application of a flat calibration frame. A flat frame is a master image made up of 20 or more exposures, captured with the telescope pointing at an even light source with exactly the same focus position and camera orientation as your lights. The master flat calibration frames must themselves be calibrated to remove their bias and thermal noise before they are integrated into a master flat frame.

Handy shortcut

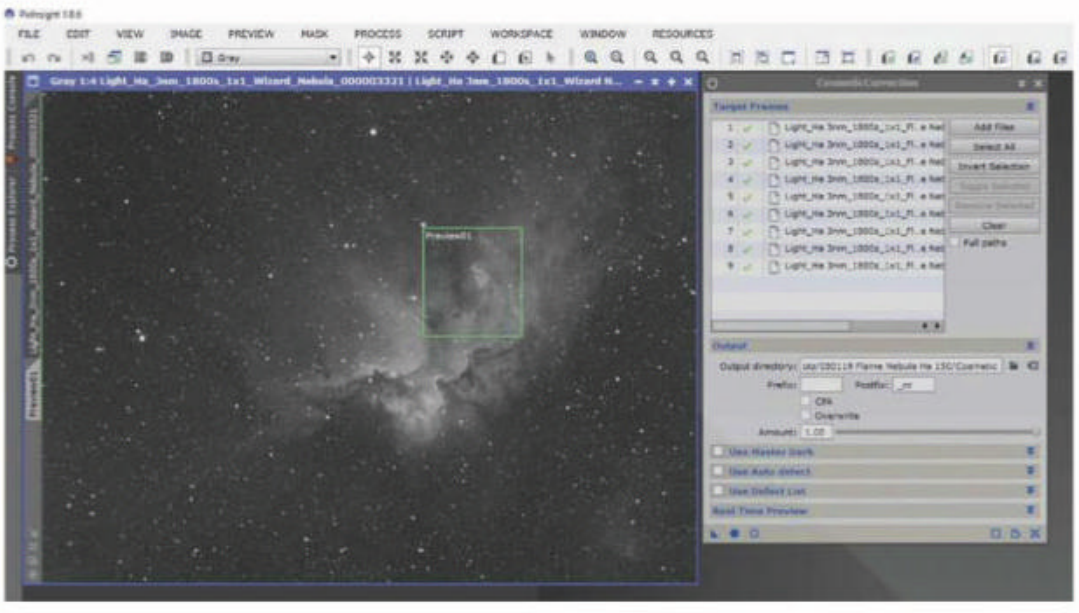
Although the calibration tasks can be carried out using individual processes, an excellent PixInsight script called 'Batch Preprocessing' will perform calibration for you automatically. Select Script › Batch Processing › BatchPreprocessing. Click on the 'Add Files' button and select all of your matching light, bias, dark and flat frames and the script will neatly apportion them to the correct table for you.



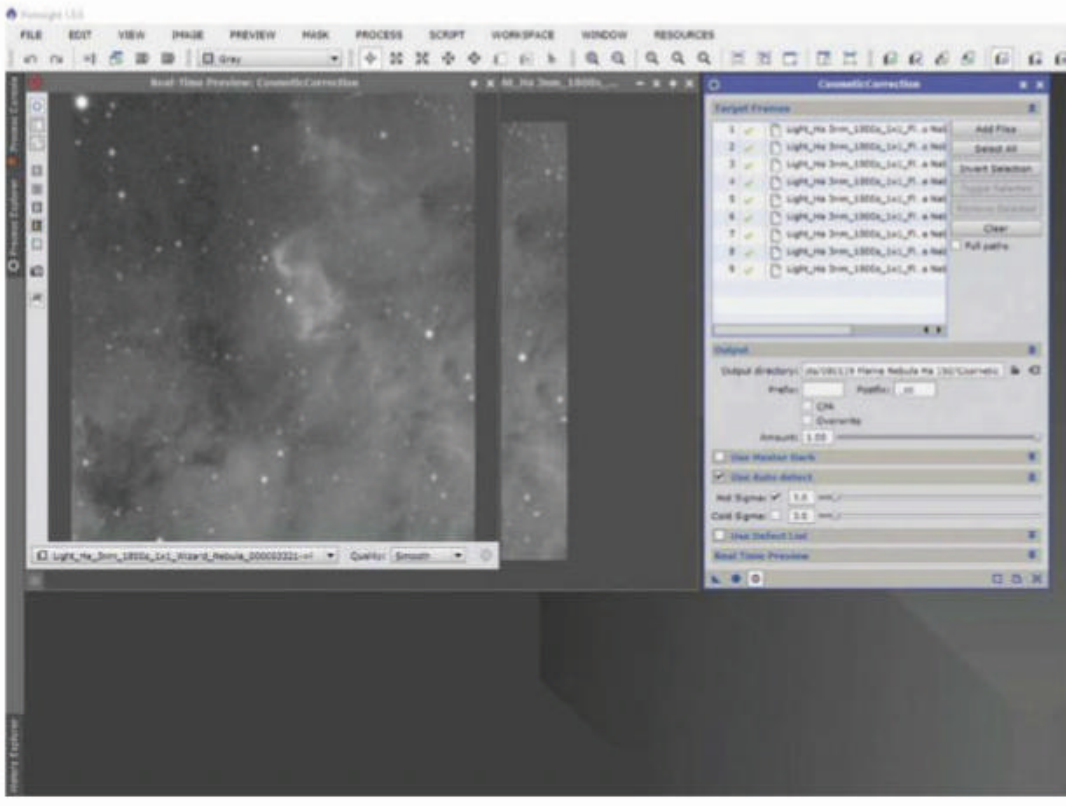
▲ PixInsight's Batch Preprocessing is an incredibly useful shortcut for automatically calibrating your light, flat and dark frames

Although the script also has alignment and integration features, it is better to carry out these procedures individually, so place a tick in the 'Calibrate only' box. Tick the 'Optimize dark frames' box, so that your dark frames will be optimised for calibrating your flat frames.

Over on the right, choose 'Output Directory' to select a root directory into which you would like your calibration masters and calibrated lights to be saved. Click 'Run'. The script automatically populates your chosen directory with subdirectories named 'Calibrated' and 'Master'. The 'Calibrated' subfolder is further subdivided into subdirectories named 'Flat' and 'Light' containing the calibrated frames of each type, but as the darks are not bias-subtracted permanently in this script, there is no need for them to be saved in a new directory. The 'Master' subdirectory will contain the three master calibration frames that can be kept as library files for use in future calibration sessions if you wish.



▲ Having dealt with most artefacts, use Cosmetic Correction to preview and stretch several areas to see rogue hot pixels that need to be removed



▲ Use the Hot Sigma slider in Cosmetic Correction to remove hot pixels, adjusting the level until you get the result you want



A single calibrated frame, ready for combining with others in subsequent processing sessions

Although applying these calibration frames will make an improvement to your data, there is still the issue of remaining hot pixels to be resolved and a hot pixel profile must be generated by selecting Process › ImageCalibration › CosmeticCorrection.

Click on the 'Add Files' button and select your calibrated lights, then select the output directory where you want the corrected files to be saved. Open one of the calibrated lights, press 'Ctrl+A' to apply an Auto-stretch, then press 'Alt+N' and drag a selection box over part of the image to produce a preview image. Select the preview image by clicking on its grey tab. Select the 'Real-Time Preview' button. Place a tick in 'Use Auto Detect' and 'Hot Sigma', and adjust the Hot Sigma level until the hot pixels disappear.

Finally, click on the 'Apply Global' button to apply the corrections to all the lights. Your lights will now be fully calibrated, and ready for registration and integration in future sessions.

Your best photos submitted to the magazine this month

ASTROPHOTOGRAPHY GALLERY

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△ A dragon and the witch's hat

Craig McDearmid, Kirkjufell Mountain, Iceland, 7 December 2018



Craig says: "This is a very atmospheric place, with constantly changing moods, and I felt this shot captured a particularly striking moment with the aurora poised right over the summit. I also liked the driftwood complete with rusted metalwork and chains, as it seemed a perfect foreground for the scene."

Equipment: Sony a7S digital camera, Samyang 14mm lens, tripod
Exposure: ISO 3200 f/2.8, 5"
Software: Lightroom

Craig's top tip: "For capturing aurora, a mix of forward planning and good luck is required. A new Moon and transport to escape the clouds are very beneficial, as well as apps such as Glendale Skye Auroras for real-time updates, or following AuroraWatch UK and Aurora Iceland on Facebook. Remember to reduce exposure time so as not to blow out the highlights if the aurora is strong. A short exposure also helps to capture the aurora's movement and structure. I always like to fix handwarmers to the camera lens so it doesn't fog up at the crucial moment."

△ The California Nebula

Dean Hucklesby, Surrey, 29 January 2019



Dean says: "Sadly my father passed away on 16 January and I wanted to take an image he would be proud of. I chose the star Menkib in honour of his memory."

Equipment: Canon EOS 5D Mk II DSLR camera, William Optics GT81 apo refractor, Sky-Watcher EQ6-R Pro SynScan mount **Exposure:** 20x900", 20x600" Ha, 75x200" OSC, darks, flats, bias
Software: DeepSkyStacker, Photoshop

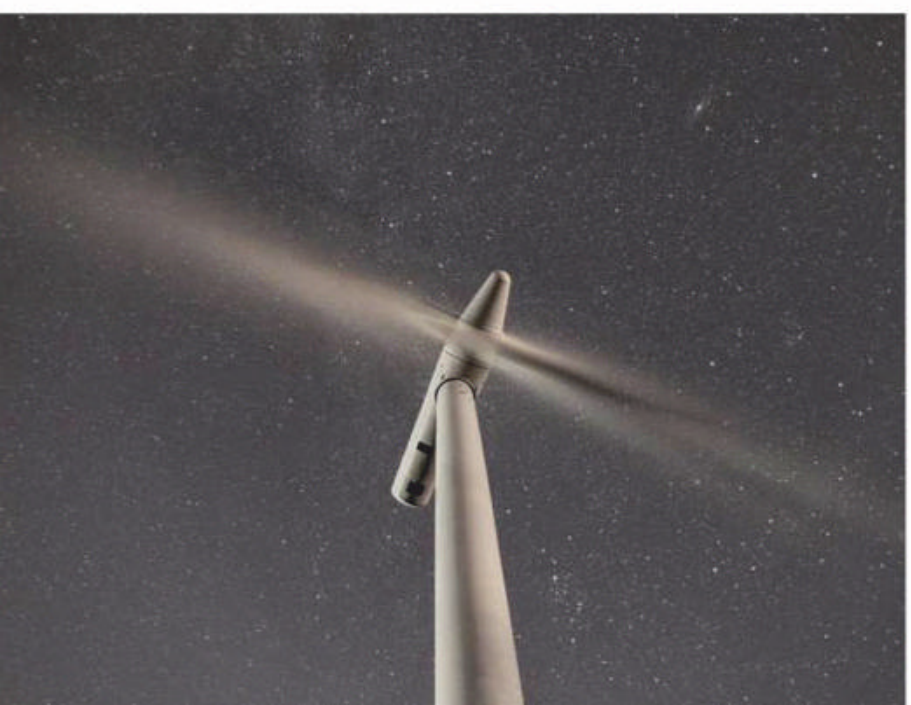
▽ Star power

David Cannon, Whitelee windfarm, Eaglesham Moor, East Renfrewshire, 7 October 2018



David says: "The windfarm is away from Glasgow's light pollution, so I decided to try a starscape image with the rotating turbine. Cassiopeia is near the head of the turbine and the Andromeda Galaxy can be clearly seen. I also love the star clusters showing up on the image."

Equipment: Canon EOS 6D Mk II DSLR camera, Samyang 24mm f/2 lens **Exposure:** ISO 2500, 15"





△ The Orion and Running Man Nebulae

Sue Silver, Sheffield, 31 December 2018



Sue says: "I have only recently begun to do imaging, and the Orion Nebula has always been one of my favourite objects. Getting the CG-5 mount was a start, but this target is notorious for being difficult to achieve the right exposure on. Still a work in progress."

Equipment: Canon EOS 1100D DSLR camera, Sky-Watcher Evostar 80ED refractor, Celestron CG-5 equatorial Go-To mount **Exposure:** ISO 800, 28x10"
Software: DeepSkyStacker, PaintShop Pro

△ Cygnus widefield

Emil Andronic, Herts, 17 November 2018



Emil says: "I thought the busy Cygnus region would make a perfect candidate to test the capabilities of my lens."

Equipment: Canon EOS 600D DSLR camera, Canon 50mm f/4 lens, Sky-Watcher EQ3 Pro mount. **Exposure:** 10x600" **Software:** AstroPhotography Tool, PHD2, DeepSkyStacker, Lightroom

NGC 253 ▷

Rafael Compassi and Maicon Germiniani, Presidente Lucena, Brazil, 6-8 November 2018

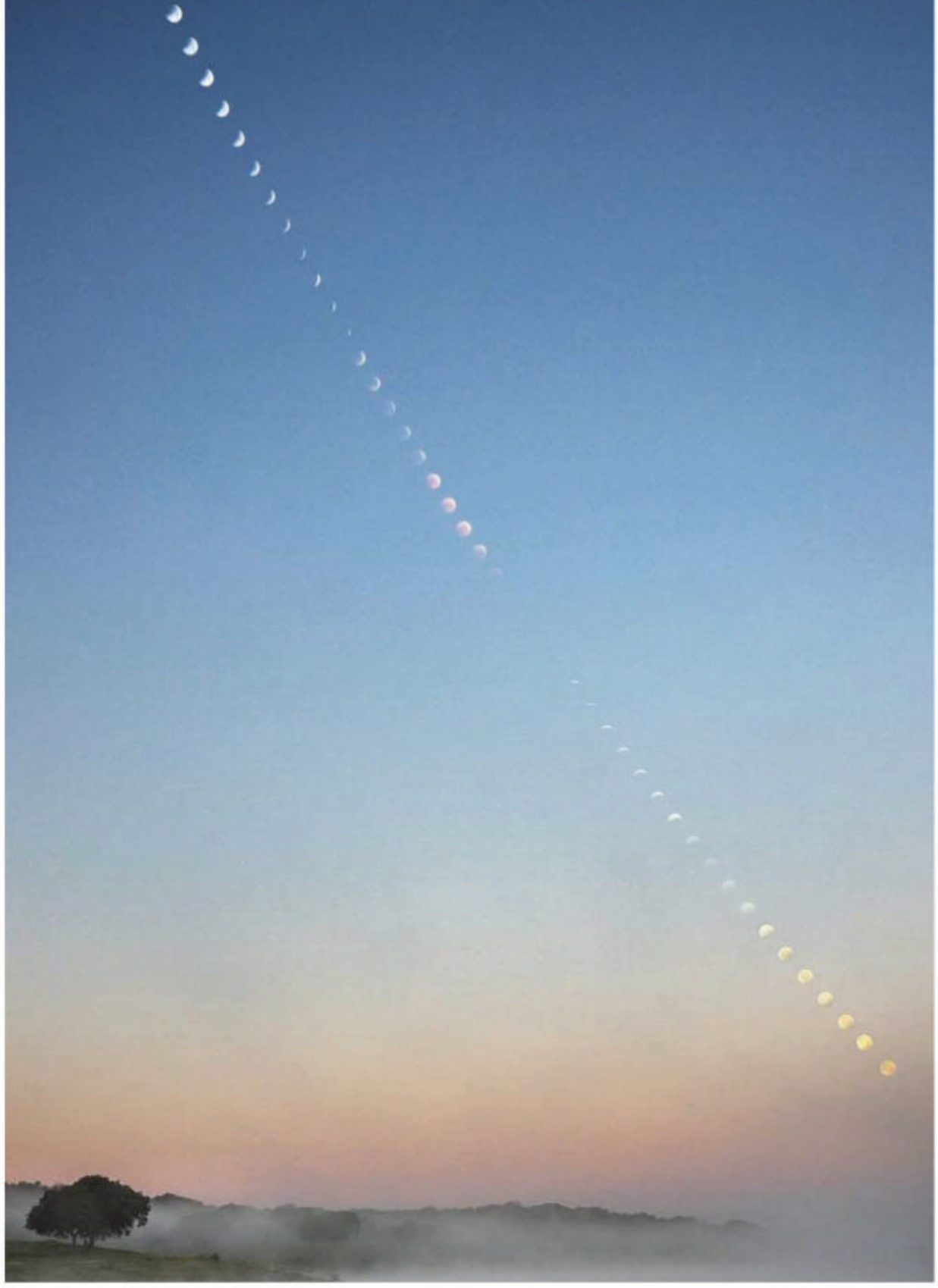


Rafael says: "We teamed up to image one object and gathered 10 hours of luminance. The result has good definition on small details and a halo showing up faintly."

Equipment: ZWO ASI1600MM camera, William Optics 132 apo refractor; ZWO ASI183MC colour camera, Teleskop Service 115/800 triplet apo refractor **Exposure:** 200x180" L, 20x180" each RGB **Software:** AstroPhotography Tool, PixInsight, Photoshop







◁ Total lunar eclipse

Sergio Conceição, Alentejo, Portugal, 21 January 2019



Sergio says: "I wanted a picture free from artificial light pollution so I opted for a location in the countryside. You can see the Moon's varied colouration all through the phases. It's always hard to photograph for hours in the cold and mist, however with resolve I achieved the result I was aiming for."

Equipment: Canon EOS R camera, Canon 35mm IS L lens **Exposure:** ISO 200 f/4, 49 shots **Software:** Digital Photo Professional, Photoshop

▷ The Western Veil Nebula

Roger Nicholson, West Sussex, 10 August 2018



Roger says: "I got a new CCD camera and chose this target as it would create a big colourful image."

Equipment: ZWO ASI183MM CMOS camera, Sky-Watcher 120ED refractor, Sky-Watcher EQ6-R PRO mount **Exposure:** 42x150" **Software:** DeepSkyStacker, Astro Photography Tool, Photoshop



△ 95%-lit Moon

Fernando Oliveira De Menezes, São Paulo, Brazil, 23 January 2019



Fernando says: "The colours correspond to differences in the chemical composition of the lunar surface. Blue reveals areas rich in ilmenite, which contains iron, titanium and oxygen, while orange and purple show relatively poor titanium and iron regions."

Equipment: ZWO ASI1600MC camera, Sky-Watcher Esprit 150 ED Pro triplet refractor
Exposure: 20', 390 frames
Software: SharpCap, Autostakkert!, RegiStax, Photoshop, Lightroom, Fitswork



△ The Jellyfish Nebula

Richard Leighton, remotely via Siding Spring Observatory, Australia, 29 November 2018



Richard says: "As I'm based in Kent and own just a camera, 500mm lens and tracking mount, I've only dreamed of capturing objects like this. Using a remotely operated scope via iTelescope.net gave me the opportunity, and also allowed me to experiment with producing colours from narrowband data."

Equipment: FLI MicroLine ML11002 CCD camera, Takahashi FSQ-106ED refractor, Paramount PME mount
Exposure: 8x600" Ha, 4x600" SII, 3x600" OIII **Software:** DeepSkyStacker, PixInsight, Photoshop



◁ M81

Joseph Stafford, Derbyshire, 2 February 2019



Joseph says: "This was the first image through my new Sky-Watcher and it certainly passed my expectations. I selected this target because it's a bright galaxy that was just high enough in the eastern skies."

Equipment: Canon EOS 1200Da DSLR camera, Sky-Watcher Explorer 200P-DS reflector, Sky-Watcher NEQ6 Pro SynScan mount
Exposure: ISO 800, 80x3'
Software: PHD2, Astro Photography Tool, DeepSkyStacker, Photoshop

▷ The Flame and Horsehead Nebulae

Kevin Stewart, Northumberland, 2 February 2019

Kevin says: "This has always been a favourite of mine. I was thrilled with how it turned out given how low it appeared in the sky and my location, which has obstacles blocking the view."

Equipment: Canon EOS 1100D DSLR camera, Sky-Watcher 130P-DS Newtonian, Celestron CGEM mount **Exposure:** ISO 1600, 36x300", 12x900" Ha
Software: PixInsight, DeepSkyStacker

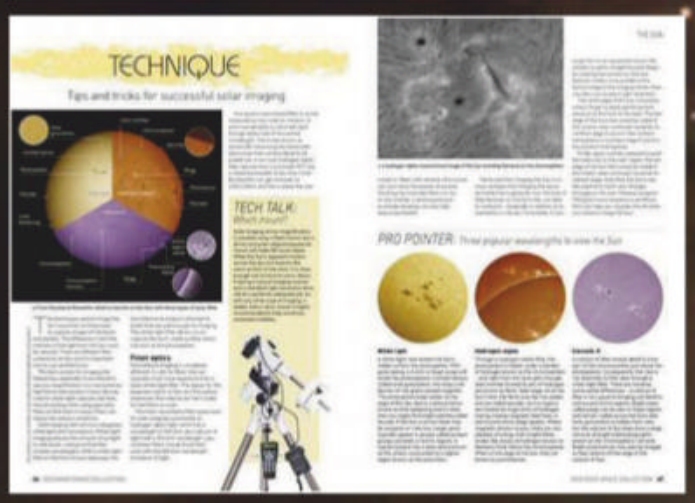
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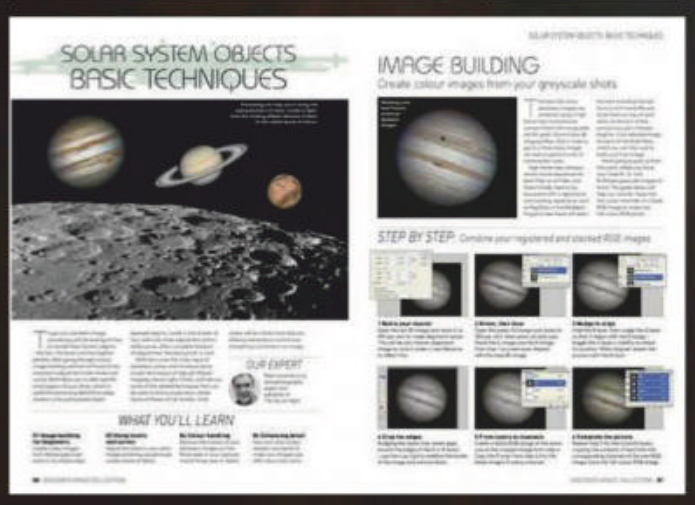
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86

Get into solar astronomy with Daystar's Solar Scout SS60-ds, an affordable scope for beginners with a tempting bundle of extras

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★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

WWW.THESECRETSTUDIO.NET X 2

Daystar Solar Scout SS60-ds H-alpha telescope bundle

This entry-level telescope has a great price point, but does its performance match?

WORDS: GARY PALMER

VITAL STATS

- **Price** £899
- **Objective** 60mm achromatic doublet
- **Effective focal length** 930mm
- **Wavelength** 656.28nm
- **Power req** 5v 1.5amp
- **Mounting** Vixen-style mounting foot
- **Included** 25mm Plössl eyepiece, 1.25-inch diagonal, 8-hour battery pack, USB power cable
- **Weight** 1.33kg
- **Supplier** The Widescreen Centre
- **Tel** 01353 776199
- **www.** widescreen-centre.co.uk

ALL PICTURES: WWW.THESECRETSTUDIO.NET

Hydrogen alpha (Ha) solar observation and imaging has never been so popular, but it can be quite an expensive undertaking. Daystar has addressed this by launching a dedicated solar telescope aimed at solar astronomy beginners, the 60mm Solar Scout SS60-ds. It looks exciting from the specifications and, most of all, the cost. There are two versions: a basic model and the bundle option that we are reviewing here, which includes a 1.25-inch diagonal, a 25mm eyepiece, a power pack and a mains charger that can power the telescope and charge the powerpack.

The SS60-ds resembles some of Daystar's previous models, but there are some major differences. At the back, the Quark optical component is fixed to the telescope and can't be removed, making this an all-in-one unit. There is a USB power port, tuning knob, power LED and a 1.25-inch eyepiece holder at the back too, with the focuser on the main body of the telescope. Mounted on the top is a solar finder and on the bottom is a Vixen-type dovetail shoe with threads for camera tripods.

Spying surface details

One of the main features of the SS60-ds is the internal Ha filter, giving a bandpass of around 0.5Å. Most solar telescopes have a bandpass of around 0.7Å, which means the SS60-ds is the equivalent of a narrower bandwidth double-stacked solar telescope. There are positives and negatives to this depending on the features you like to view or image on our nearest star; there will be less detail in prominences with this scope's bandpass of 0.5Å, but more detail in filaments and surface structures. The brighter prominences are still visible and appear more connected to the Sun's surface.



See an interactive 360° model of this scope at www.skyatnightmagazine.com/daystarSS60

Setting the telescope up is very easy. After mounting it we plugged in the power pack and set the tuning knob to the centre. Once heated, it was 'on band' and the LED turned from red to green, showing that it was ready to use. Locating the Sun in the solar finder was simple with Daystar's 'Solar Bullet' finder. As once we neared the Sun a white ▸

Filter in focus



Using clever design and management of the internal filters allows the SS60-ds to attain a wavelength of 656.28nm (1nm = one billionth of a metre) at around 0.5Å (1 Ångström = 0.1nm) or below – an area that has not been reached with any solar telescope at this price. The scope also benefits from a 12mm blocking filter with a 16mm clear etalon aperture; most are around 5–6mm. This is of great benefit when imaging with cameras that have larger sensors or when using a powerful eyepiece as it helps create less distortion in the view or image. Using the internal heater to change the temperature helps keep the filter on band without having to adjust anything. As with any Ha solar telescope, a mono camera will work best for imaging and a tilt adaptor is recommended to stop light bouncing directly between the camera sensor and the rear internal filter, an optical aberration known as Newton's Rings.

SCALE



385mm



Bundled accessories

With the bundle pack you can get the telescope set up and running straight away as everything you need is included in the box. The power pack lasts around eight hours on a full charge. Also included is a 25mm Plössl eyepiece, a 1.25-inch diagonal and a power cable.



LED

The LED is red when first powered up, then will show yellow for 5–10 minutes before turning green, indicating that the filter has settled to its required temperature and is on band for viewing. The time taken to achieve this will depend on the outside air temperature.



Tuning knob

Adjusting the tuning knob brings out more details in different areas of the Sun. The centre wavelength can be adjusted by 0.1Å with each click, adding or subtracting contrast in the view. After every alteration the telescope resets the temperature and the LED will change to green when ready.

Focuser

Located in the middle of the telescope, the focuser uses a well machined thread with a sleeve bearing making it easy to hold. This allows for zero image shift and stops rotation of cameras and eyepieces. Using this position also allows for a camera to be used at prime focus or with a Barlow.

FIRST LIGHT

KIT TO ADD

1. Sky-Watcher SolarQuest Go-To/Tracking mount & tripod

2. Daystar Interference Eliminator, T or C thread

3. Lunt H-alpha optimised zoom eyepiece

▸ circle appeared on the screen. By centring the circle the Sun was in the scope's field of view. With the included eyepiece and diagonal we could then safely begin observing. Adjusting the focuser allowed fine detail to appear. The focuser is designed to stop image shift – the apparent movement of an image caused by the internal slipping of optics in some budget telescopes. While it worked well, it seemed a little stiff, but that could be due to the cold temperatures during our test.

We selected a small sunspot group to view and were able to locate it once the tuning knob had adjusted the wavelength. When tuning, it took 5–10 minutes for the telescope's LED to turn back to green to show it was again on band. There were some small prominences to view and, with the addition of a 2x Barlow lens, we could see some lovely structural detail in them given the aperture and the low winter sun. Daystar has always had good contrast in their solar products and we were pleased to find that the SS60-ds maintains this, helping to make objects on the surface stand out more.

Even though the SS60-ds is a budget solar scope, it is more than capable of producing some nice images for the aperture. Setting up for imaging is very easy as the telescope allows for a camera to reach focus without the addition of a Barlow lens. Having a long focal length of 930mm means you will need a large camera to capture a full disc image of the Sun. We achieved this using a 1600 ASI camera; changing to an imaging camera with a smaller sensor meant that the telescope was able to get quite close-up images too.

The Daystar SS60-ds has quite a lot to offer for anyone thinking of upgrading from a white light solar setup and, at a keen price, it will fit into the budget of many astronomers.

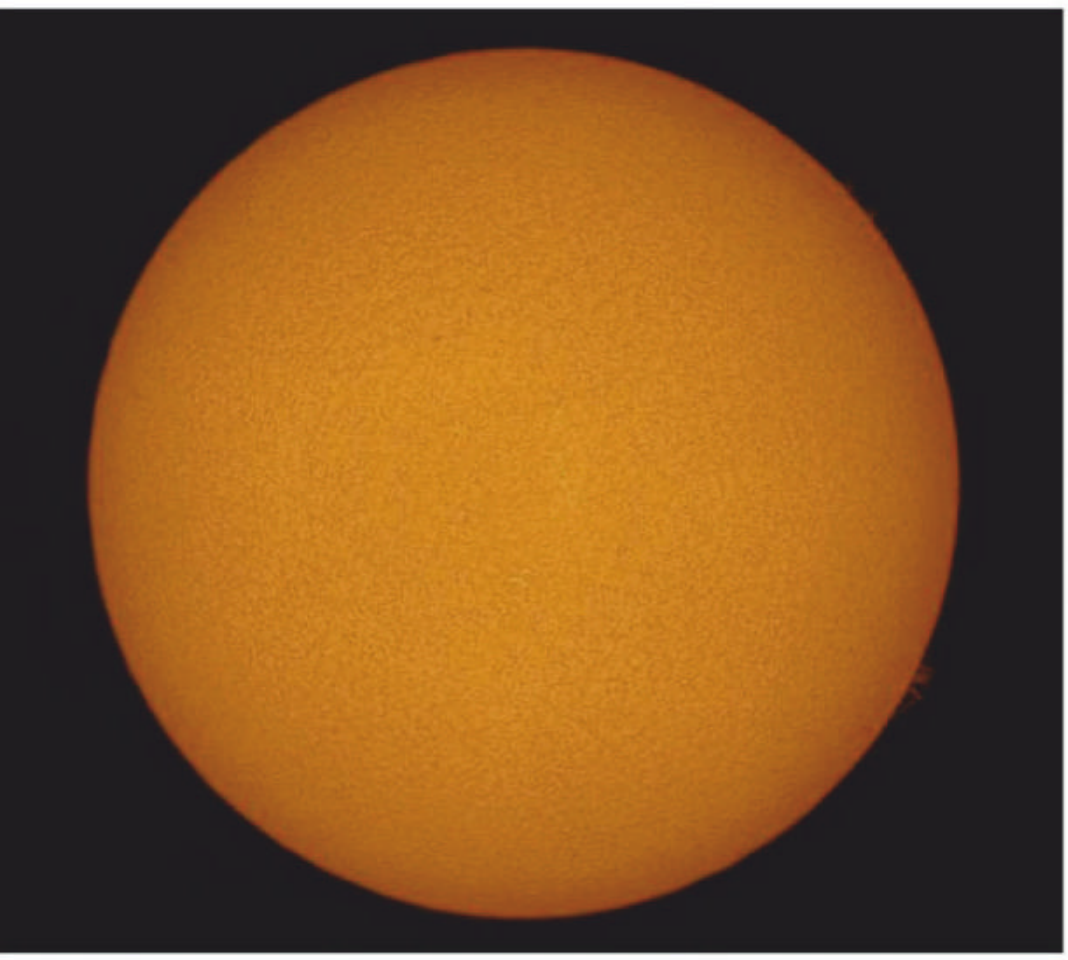


Lens and internal Barlow

A 60mm achromatic doublet lens is used in the front of the telescope, with an internal 4.3x telecentric Barlow giving an effective F ratio of f15.5. This all allows for a full disc view using a 25mm eyepiece. An internal baffle system and dew shield helps maintain good contrast when observing or imaging.

VERDICT

Build and design	★★★★☆
Ease of use	★★★★☆
Features	★★★★★
Imaging quality	★★★★☆
Visual quality	★★★★☆
OVERALL	★★★★☆



▲ A 20-panel mosaic captured with an IMX290 sensor (frames have been stacked in AutoStakkert! and assembled in Photoshop)



Pairing the Solar Scout SS60-ds with an IMX290 sensor captured this prominence



Sunspot group captured with an IMX290 sensor and a 2x Barlow lens

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WORDS: PAUL MONEY

VITAL STATS

- **Price** £310
- **Load capacity** 2.5kg
- **Tracking rate** Sidereal, Northern and Southern Hemisphere
- **Polar scope** Illuminated polar scope
- **Extras** Power pack case, hand controller with 2x/32x slewing adjustment, accessories tray, sighting tube
- **Total weight** 4.5kg
- **Supplier** Telescope House
- **Tel** 01342 837098
- **www.**telescopehouse.com

ALL PICTURES: WWW.THESECRETSTUDIO.NET



There are so many tracking mounts for taking wide-field and telephoto long exposures of the night sky, one would think the market might be saturated. Yet Bresser has joined in with their Photo Mount and we were keen to see how it compared with others we have tested.

The Photo Mount can be purchased with or without a dedicated tripod/polar wedge, so if you already own a good tripod you can get the version without and save some money. However, here we review the complete package which includes the tripod/polar wedge, an illuminated polar finder scope, polar sighting tube, hand controller, ball head socket and a power pack that takes eight D-type batteries.

Setting up was straightforward and took little time as the tripod and polar wedge came preassembled. The polar scope attached to the base of the mount and, if needed, could be adjusted so as to not interfere with any camera when fitted. The Photo Mount head attached to the polar wedge and then the ball head socket which has a quick-release saddle plate screwed in place ready for a camera.

Weighty issue

The suggested maximum load of camera and lens is 2.5kg and our Canon 50D DSLR and 100–400mm EOS lens were spot on that weight, while changing to our 70–300mm lens brought the weight down to 1.5kg. The camera with its standard 18–55mm lens was 1kg, so all the weight combinations worked out as either just on, or well within, the load capacity limit.

Our camera was attached to the ball head socket via its quick-release plate, ready for our first night of imaging. It should be noted that during our first attempts at reviewing this product we discovered a significant tracking error, the cause of which was identified as the gear ratio being incorrectly set up, even with wide-field lenses. Telescope House liaised with Bresser, who had just discovered that a ▸

See an interactive 360° model of this mount at www.skyatnightmagazine.com/BresserMount

Fine alignment

For any equatorial tracking mount, the key to great astrophotos is accurate polar alignment. Bresser's Photo Mount has two ways of achieving polar alignment: a rough sighting tube for a quick alignment and a more accurate polar alignment scope. For very wide-field astrophotography, the rough polar alignment is sufficient for several minutes of tracking before any star trailing occurs. If you increase the focal length or length of exposure, the best option is to use the polar scope.

The polar scope has an etched view of the Great Bear and Cassiopeia, and you can rotate the scope in its holder to match their orientation. The clever bit is that there is a line with a gap to place Polaris in, along with a second line where you can position Delta (δ) Ursae Minoris. Get both in their allotted spots and you have excellent polar alignment, allowing the use of longer exposures or larger lenses. We found this to be one of the best ways to polar align in our several years of reviewing equipment.





Altaz adjustments

Adjustments for altitude and azimuth are easy. There is a bubble level to ensure the tripod is level and the polar wedge has a latitude scale that enables a rough initial set-up before fine adjustments are made.

Photo Mount and gears

The Photo Mount is a solid unit that attaches to the polar wedge via two ¼-inch screws. The rotary knob can be used to manually fine adjust the right ascension (RA) when loosened, then tightened to engage the motors for tracking. The RA clamp is used for larger-scale adjustment.



Power pack

Power is provided by eight D-type batteries (not included), held in a soft case and connected to the hand controller. In the field we had no issues with power loss over several nights' usage. Bresser estimates that you should get 50 hours before replacement batteries are needed.



Ball head

The supplied Bresser ball head with quick-release saddle plate worked well. It has two knobs for adjustment: one for rotating the whole ball head around its base and the other for adjusting the tilt of the camera. With heavy lenses there was a slight slippage, but it was minor.

FIRST LIGHT



Orion's Belt and Sword region, 70mm lens, f5.6, 15-minute exposure at ISO 800

KIT TO ADD

1. Revelation smartphone holder

2. Explore Scientific Astro R-Lite red light flashlight

3. Bresser BR-B76 tripod bag

▸ second production run also had gear ratio issues. A new set of gears was sent out to us and installed quite easily. Our first imaging run with the new gears confirmed the Photo Mount was now working perfectly.

Once polar-aligned (see 'Fine alignment' box), we began imaging with our 18–55mm lens set at 18mm. This allowed us to take in Orion, Taurus, most of Auriga and Gemini. We achieved 10-minute, 20-minute and 30-minute exposures with no star trailing at all, although the latter did suffer from a dewed-up lens. We achieved an excellent result when we swapped to our 70–300mm lens set at 70mm and aimed at the southern half of Orion, which gave 15 minutes with no trailing.

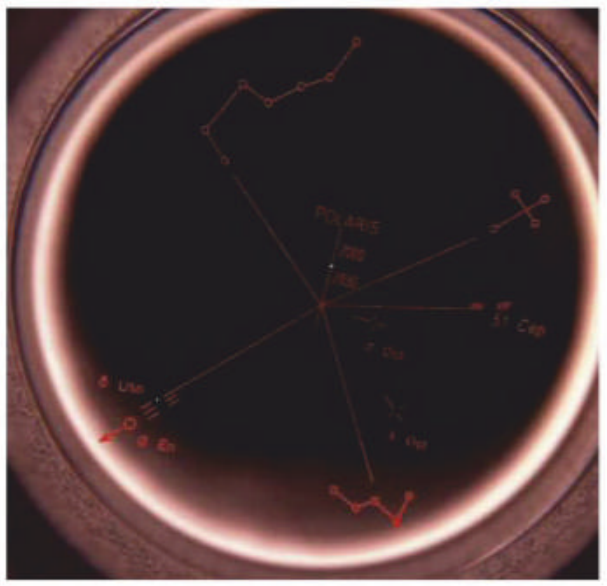
Once we increased the size of the lens, we could make slight adjustments by using the hand controller, with its 2x and 32x forward and 32x backward slewing controls. This helped for centring the view. The small green light on the controller was a little bright, but not too troublesome for our night vision. Bresser recommends using up to a 200mm lens, so we set the 70–300mm at 200mm and still achieved five-minute exposures of the Pleiades (M45) star cluster in Taurus with no trailing.

Pushing the lens to 300mm and aiming at the Sword of Orion, we still managed three-minute exposures with no trailing. However, swapping to our EOS 100–400mm lens pushed the load capacity to the maximum, and while at a 100mm focal length we could achieve three-minute exposures with barely any sign of trailing, the additional weight clearly took the mount to its limit. We did find that with the heaviest load there was a little slippage in the ball head over long periods, but this is a very minor niggle in what is a good system.

Overall, this mount is aimed primarily at wide-field and medium telephoto astrophotography, and for this it really delivers. We were impressed with its performance and found it one of the best we've tested in the field.

▸ **The Pleiades star cluster, stack of 6x 5-minute exposures using a 70–300mm lens set at 200mm, f5.6 ISO 400**





▲ **The etched scope for fixing polar alignment really impressed our reviewer**

Hand controller

The DK8-B hand controller provides power and control to the RA motor. The four buttons pause the motor and make 2x and 32x forward and backward fine adjustments.



VERDICT

Assembly	★★★★½
Build and design	★★★★★
Ease of use	★★★★½
Features	★★★★★
Tracking accuracy	★★★★★
OVERALL	★★★★★

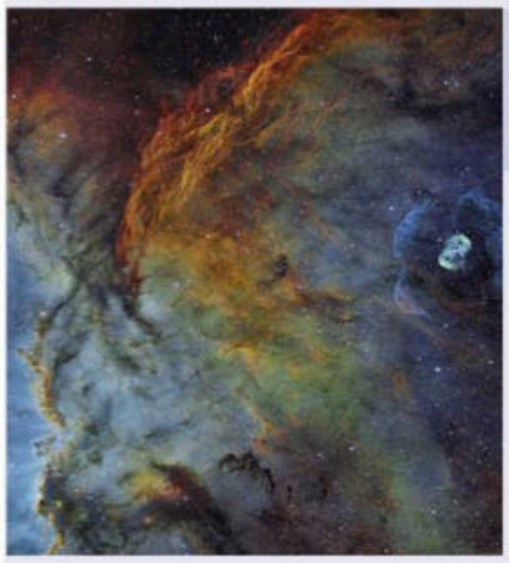
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The Cosmic Mystery Tour

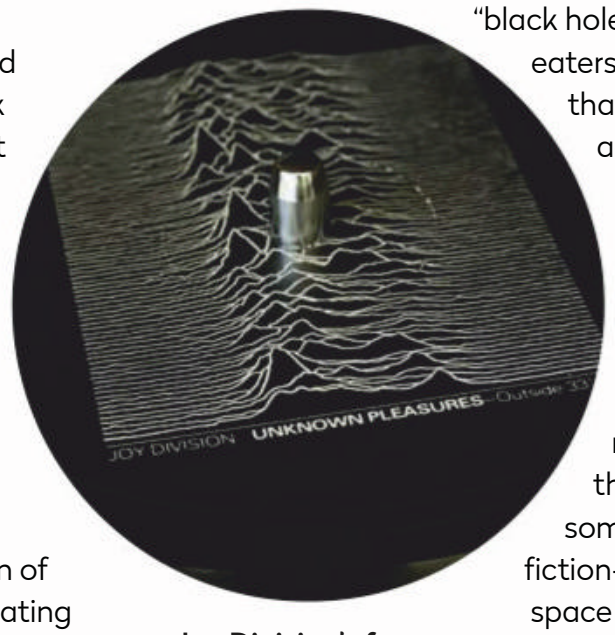
Nicholas Mee
Oxford University Press
£16.99 ● HB

Ambitious in scope and easy to read, this book is a small guide to that largest of subjects: the physical Universe. It's divided into three sections: the first provides a roller-coaster ride through the fundamental laws of physics; the second examines the evolution of the Universe, concentrating on the creation of stars and black holes. The final section summarises the work being done to detect exoplanets (to date, several thousand have been found by NASA's Kepler mission) and the likelihood of finding life on them.

The many pictures are not just the usual beautiful scientific images from NASA and ESA that we've come to expect in popular science, but include relevant artistic and cultural references. For example, the discussion of the first pulsar discovered shows the iconic image of its output as used by the band Joy Division on the cover of their album *Unknown Pleasures*.

Mee is an experienced science communicator and this shows in his confident and engaging tone. The brevity of the book (224 pages) invariably makes for simplification, and occasionally some over-simplification. This may give the false impression that the development of the subject, and our corresponding understanding of the Universe, has been a straightforward journey from ignorance to enlightenment, whereas in reality the practice of science can be a messy endeavour influenced by scientists' characters and prejudices. For the interested reader who wants to find out more, each chapter does have recommended further reading.

Generally the style of writing is informal and direct, and attention-grabbing analogies help to communicate the complex physics. I particularly liked "black holes are very messy eaters" to convey the fact that event horizons are actually rather small and much of the progenitor star may – or may not – get slurped into it.



▲ **Joy Division's famous 'pulsar' album cover is among the eclectic images**

KAY ROXBY/ALAMY STOCK PHOTO

This enjoyable, fast-paced account manages to look to the future by including some truly science fiction-worthy ideas of space probes from the Solar System to the stars. It would be ideal for anyone wanting to know more about the underlying physics of the pretty pictures we see in the media.

★★★★☆

***Pippa Goldschmidt** is an astronomy and science writer*

Interview with the author Nicholas Mee



Who have been the most important figures in our understanding of the Universe?

Kepler, who first accurately described planetary orbits; Newton, whose grand system of gravity and mechanics launched the era of modern science; and Einstein, whose theory of gravity predicted the existence of black holes, the expansion of the Universe and much else. But many important contributions have been overlooked in the past, especially those made by women such as Henrietta Swan Leavitt, Cecilia Payne and Jocelyn Bell.

Are we on the cusp of great cosmological discovery?

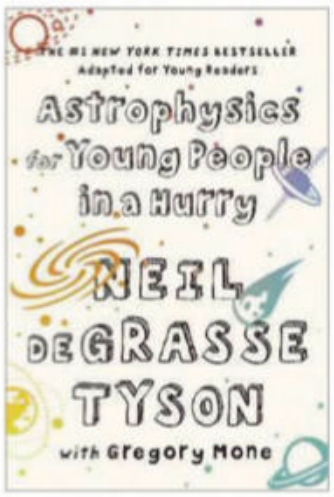
We are living through a golden age of astronomy and astrophysics. This is due to incredible advances in the equipment available to observe the cosmos. Today's astronomers have a whole range of amazing instruments such as the gravitational wave detectors that are currently detecting gravitational shock waves from black hole collisions.

How close are we to understanding how the Universe began?

The Universe is expanding and there is solid evidence tracing its origin back to the Big Bang 13.8 billion years ago. The rate of expansion appears to be increasing, which suggests it will expand forever until eventually the stars fizzle out and all matter is dissipated. But there are deeper questions. Are we part of some greater multiverse? Did anything exist before the Big Bang? Did time begin at the Big Bang? As yet, we just don't know.

***Nicholas Mee** is co-author of*
The Physical World: An Inspirational Tour of Fundamental Physics

Astrophysics for Young People in a Hurry



Neil deGrasse Tyson
WW Norton
£8.99 ● PB

Neil deGrasse Tyson is one of the premiere popularisers of astronomy today. Less known in the UK than in his native US, he has inspired a generation of space enthusiasts. His latest book, adapted by Gregory Mone from Tyson's bestselling *Astrophysics for People in a Hurry*, caters for the very young, giving a concise and simple description of many areas of modern astrophysics.

Educating and informing young children, and at the same time entertaining them, is tricky. For astronomy, it is often enough to simply pander to a child's innate sense of wonder at the cosmos. This book employs that strategy but is somewhat lacking in its structure and depth. There is no subject development and the topics are discussed almost at random, with a cynical use of single-word paragraphs and other space-wasting devices. As an adaptation of a very successful book for adults, this book is ultimately disappointing.

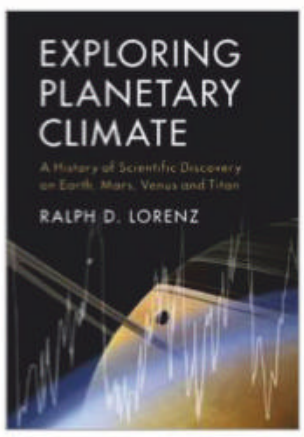
However, it's not entirely without merit. The authors deliver an informative guide to modern astronomy, and most scientific terms or principles are adequately explained in easy-to-follow but not patronising language. There are useful discussions on topics such as Big Bang cosmology, relativity, extraterrestrial life, dark matter, dark energy and black holes.

Anyone under the age of 16 with a keen interest in things astronomical is bound to derive some satisfaction from this book. However, more advanced youngsters will probably crave something more substantial.

★★★☆☆

***Dr Alastair Gunn** is a radio astronomer at Jodrell Bank Observatory in Cheshire*

Exploring Planetary Climate



Ralph D Lorenz
Cambridge University Press
£42.99 ● HB

At the dawn of a new millennium, human awareness of our planet and other worlds, within and beyond the Solar System, is growing faster than ever. In *Exploring Planetary Climate*, the story of exploration across two millennia of human genius – from ancient Greek and Roman writers to Arab and European Renaissance scholars to thinkers and doers of the modern era – is outlined with breathless pace and narrative urgency, zeroing-in on Venus, Mars, Saturn's large moon Titan, and on Earth itself.

The author, known for working on the Cassini-Huygens mission to Saturn, admits he is a man of science, not of history, yet walks his reader through a burgeoning historical corpus of discovery with a keen storyteller's eye and an excited yearning for exploration. Lorenz tells us that his physics calling came as a schoolboy and was ignited in adulthood by a fascination with climate change, and this forms a strong thread through the book.

He describes how localised geological events can have profound planet-wide consequences and underlines a growing awareness of the link between the Sun and climate change, juxtaposing his story with a look at Venus's runaway greenhouse effect, Mars's weather and the "sweetest fruit" of pristine, primordial Titan.

Climate change has never been a more pressing issue and its wider significance is not lost on the author. He dismisses climate change naysayers, describes America's withdrawal from the Paris Accord as a temporary setback, and stresses that "the truth will out". Lorenz morphs well from physicist into historian, while also intelligently considering the future and the problems that continue to impair the present.

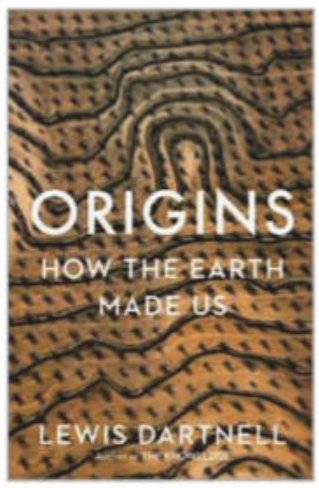
★★★★☆

***Ben Evans** is a science and astronomy writer, and author of several books on human spaceflight*

Origins: How the Earth made us

Lewis Dartnell
Bodley Head
£20 ● HB

BOOK OF THE MONTH



Have you ever wondered how Earth's orbit dictates what you eat for breakfast, or how ancient geology shapes voting patterns in the US and UK? No, me neither, until I read Lewis Dartnell's *Origins*. Now these thoughts and many more besides will keep me awake at night.

The book takes the reader through our planet's formation and shows how the quirks of its orbit, tilt and wobble, along with plate tectonics and the circulation systems of our atmosphere and oceans, have driven everything from our species' evolution to the way we power our modern world.

These days we are so used to talking about how we are affecting the natural systems of our planet, but this book shows the other side: how our planet has dictated what crops we grew and the animals we domesticated, what natural resources we exploited, where we built our ancient civilisations, developed trade routes and went on to explore and colonise the globe.

Origins is like a well-crafted jigsaw puzzle. Each piece fits together beautifully to build up a complete picture of the deep connections we have to the blue marble we call home. The text is clearly written, with so many 'I had never thought about that before!' moments. The science behind every step of our evolution and history is well explained, and there are helpful maps and diagrams peppered throughout.

The book ties anthropology, geography, geology, history, chemistry, biology and physics all together in a thoroughly satisfying read for anyone interested in how our planet drove our history, and how everything is connected.

★★★★★

***Jenny Winder** is a freelance science writer, astronomer and broadcaster*

Elizabeth Pearson rounds up the latest astronomical accessories

GEAR



1 Explore Scientific 3mm 52º long eye relief eyepiece

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4 Orion magnetic 3lb counterweight

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5 Thumbscrews for secondary mirror

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6 Red Eyes Cling touch-screen filter

Price $5.95 • **Supplier** Sirius Astroproducts
www.siriusastroproducts.com

You can maintain your dark adaptation (your eyes being used to low light) and still use your touch-screen devices with this red-light filter. The film clings to the screen through static, meaning it can be easily removed and used again. An extra-dark version is also available.

What if we all went vegan? Do plants have memories? Is all plastic bad? Is technology changing how we think? Does screen-time harm kids? Can intermittent fasting overcome a bad diet? Is love a chemical reaction? What's beyond the edge of the Universe?

Ideas, discoveries, and the big questions answered...

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Shaoni Bhattacharya interviews leading experts in space science

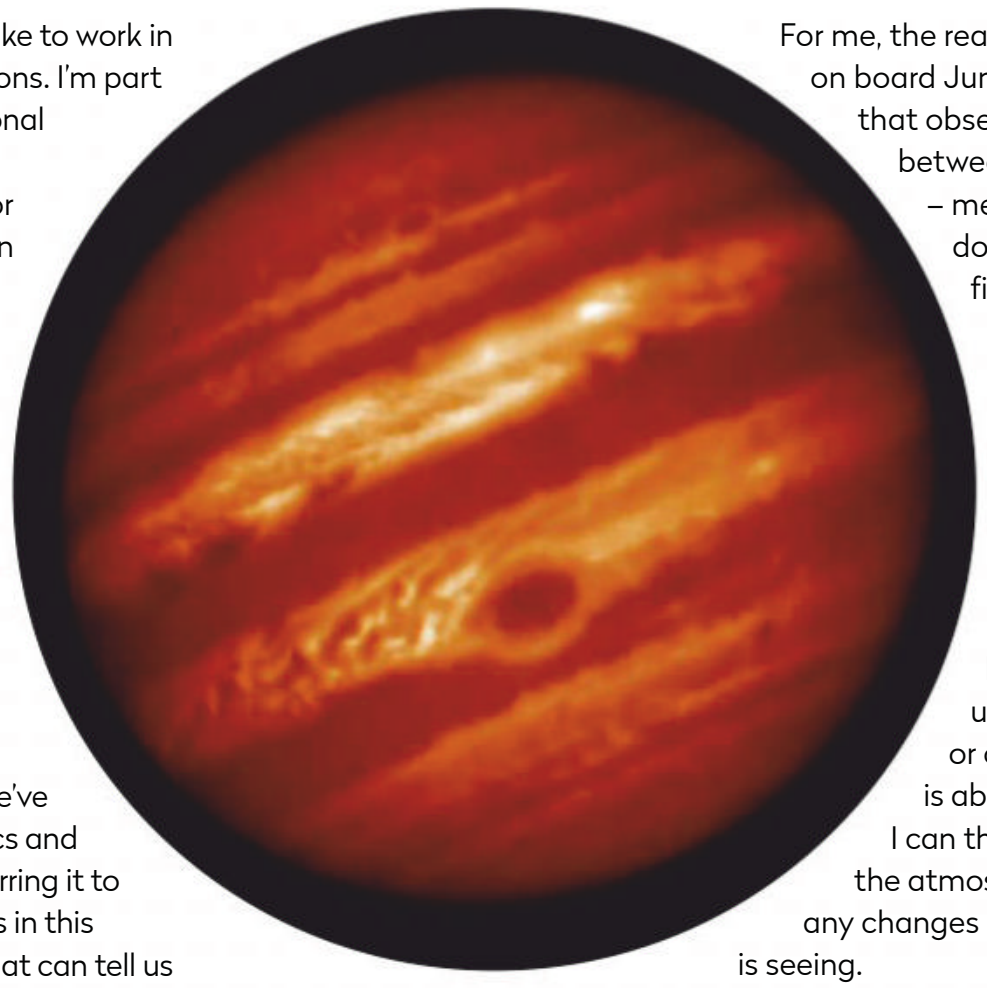
WHAT I REALLY WANT TO KNOW IS...

What can Jupiter's storms tell us?

Dr Leigh Fletcher from NASA's Juno mission is finding out what the weather's like on the largest planet in our Solar System

Astronomers do like to work in gorgeous locations. I'm part of the international ground-based support team for the Juno mission – NASA's probe, orbiting Jupiter since July 2016 – and I use the Very Large Telescope out in Chile and the NASA infrared telescope out in Hawaii.

Jupiter is a perfect planetary-scale laboratory for studying the atmospheres of other worlds. Its storms offer a study of how the weather and climate work on the giant planets of our Solar System. In a way, we are taking everything we've learnt about atmospheric physics and chemistry here on Earth, transferring it to Jupiter, and seeing if it still works in this extreme environment. Maybe that can tell us something about our own planet. Jupiter should follow the same rules, and by and large we see it does, but the absence of a solid surface or ocean makes it a very different place.



NAOJ/NASA/JPL-CALTECH

▲ **Infrared analysis coupled with Juno's deep investigations is revealing more than ever before about the gas giant**

A glimpse beneath the clouds

While Juno is a wonderful beast, it flies so close to Jupiter that it lacks the global context for the observations that it's taking. It's within only 2,000–4,000km of the cloud tops, so if you think about looking out of the window on that spacecraft, Jupiter just fills your field of view from horizon to horizon. You are only seeing a tiny little sliver of planetary real estate. From Earth we get to see the whole planet at once – that's the context we are able to provide.

While the instruments on board Juno are fabulous, they don't cover all the wavelengths we'd like to look at to understand Jupiter; one particular wavelength that is completely missing is the thermal infrared. We use that to measure things like the temperatures, and to map distributions of clouds and chemicals within the atmosphere. That is a piece of the puzzle for understanding the climate of Jupiter that we can provide to the Juno project.

For me, the real headline science instrument on board Juno is the microwave instrument that observes Jupiter in wavelengths between 1 to 50 centimetres – meaning it can actually peer down below the clouds. It's the first time that we've really been able to do that with any giant planet.

My data is probing all the way down to the clouds, and then Juno can tell us what's going on beneath the clouds. If I see something changing in my dataset, say one of these long-term cycles is about to unleash a big storm system, or one of Jupiter's belts or zones is about to change dramatically, I can then compare what I see in the atmosphere above the clouds to any changes below the clouds that Juno is seeing.

You can start to think of some of Jupiter's weather systems as potentially being the tip of the iceberg, and that the circulation patterns responsible for them actually extend hundreds of kilometres below where we've previously been able to do our work.

That's the really incredible thing about Juno, that capability of getting deeper than ever before. The end goal is to get a three-dimensional picture of how the upper atmosphere responds to what's going on in the deeper atmosphere.

What my team's research is starting to reveal is how Jupiter's weather is changing with time. It evolves and shifts in the same way that weather patterns do on Earth. And we are beginning to identify cycles of activity that might exist over multi-year timescales that people just haven't witnessed before because they haven't had these long-term datasets.

The Juno mission will continue until at least July 2021 and is about halfway through the planned 32 close flybys. I'm part of another mission called JUICE, ESA's Jupiter Icy Moons Explorer. The hope is that ground-based research will plug the gap until JUICE. With luck, that will launch in 2022, to arrive at Jupiter in 2029. You have to be in it for the long haul.



Dr Leigh Fletcher is a collaborator for the Juno team and leads the planetary atmospheres team at the University of Leicester

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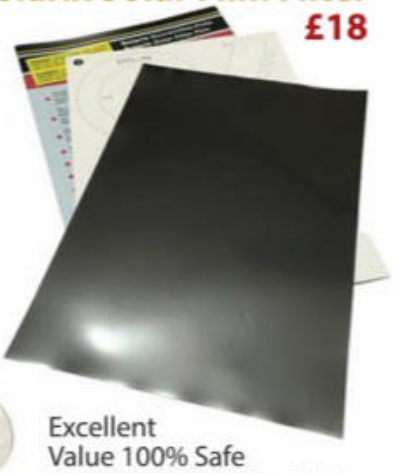


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THE SOUTHERN HEMISPHERE



With Glenn Dawes

April's Southern sky offers a chance to see Saturn impressively occulted by the Moon

When to use this chart

1 Apr at 24:00 AEDT (13.00 UT)
15 Apr at 24:00 AEDT (13.00 UT)
28 Apr at 23:00 AEDT (12.00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

APRIL HIGHLIGHTS

On 25 April an occultation of Saturn by the Moon is visible from eastern Australia. Occurring close to moonrise, this ringed world disappears behind the bright lunar limb of the third-quarter Moon, close to the eastern horizon. It remains out of sight for around an hour before brilliantly emerging from behind the dark limb. This impressive reappearance is seen from Rockhampton at 23:15, Brisbane at 23:20, Sydney and Melbourne at 23:26, Hobart at 23:28 (all EST) and Adelaide at 22:54 CST.

STARS AND CONSTELLATIONS

Alpha Centauri is famous for being the closest star to our Solar System. This honour, however, doesn't belong to either member of its bright binary pair but to its faint companion, Proxima Centauri. Only 4.2 lightyears distant, the star lies 2.2° southwest of brilliant Alpha. Locating this 11th-mag. red dwarf needs a good finder chart to separate it from the faint field stars. Only one-seventh the size of the Sun and 12% of its mass, Proxima is also a flare star, undergoing sudden eruptions in brightness.

THE PLANETS

Mars is now low in the western evening sky, with its altitude at the end of twilight being less than 10°. Jupiter, rising around 21:30 midmonth, is now well up by midnight. Saturn follows its fellow gas giant two hours later and is best viewed in the morning. Turning to the predawn, the beacon of Venus is prominent low in the east. Mercury spends the month below its fellow's inner world, being closest on 17 April approximately 4° away. Try observing this pair around an hour before sunrise.

DEEP-SKY OBJECTS

This month, a voyage in Hydra. Find the double star Chi (χ) Hydri (RA 11h 05.3m, dec. -27° 18'). It looks great in binoculars, having mag. +4.9 and +5.7 components, separated by 8'.

From Chi move 1.8° east-northeast to discover the galaxy NGC 3585 (RA 11h 13.3m, dec. -26° 45'). It is quite bright (mag. +9.8), with a star-like nucleus in a bright, condensed core. For an elliptical its halo is quite oval (3'x1.5'). Now for a challenge: lying 6° west of Chi is isolated, red, mag. +4.8 star HR4162, the marker to the Hydra 1 Galaxy Cluster. Its three brightest members are found 10' southwest. NGC 3309 and 3311 form a close pair 1.6' apart, with NGC 3312 a further 5' to the southeast. From here there are a number of other galaxies within 1°, depending on your aperture size.



Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
URSA MAJOR
M51
M106
BOÖTES
CANES VENATICI
M63
M94
Cor Caroli
Kite
LYNX
LEO MINOR
M3
COMA BERENICES
Arcturus
M64
Denebola
LEO
Sickle
13h
M44
16h
M105
M95
M96
Regulus
Ecliptic
M86
M87
M84
M90
VIRGO
CANCER
CANIS MINOR
ORION
Procyon
M5
19h
Spica
M104
CRATER
HYDRA
Alphard
Celestial Equator
LIBRA
CORVUS
M83
Ghost of Jupiter
M48
MONOCEROS
Hydra I
HR4162
NGC 3585
CENTAURUS
Cen A
Antares
M4
LUPUS
ANTLIA
VELA
PYXIS
M93
M47
Winter Triangle
CRUX
Hadar
Rigel Kent
Coal Sack
Jewel Box
Acrux
Sirius
M41
CANIS MAJOR
NORMA
CIRCINUS
MUSCA
False Cross
PUPPIS
CHAMAELEON
CARINA
ARA
TRIANGULUM AUSTRALE
APUS
NGC 3195
VOLANS
Canopus
COLUMBA
SCORPIUS
SCOPIUM
South Celestial Pole
MENSA
PICTOR
Peacock Star
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